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A MARKET ANALYSIS OF ELECTRICAL ENGINEERING GRADUATES *

By R. G. KLOEFFLER

Professor and Head, Department of Electrical Engineering, Kansas State Agricultural College

Foreword

The material for this paper was collected and prepared for a special report in "Sales Management" at the Harvard Graduate School of Business Administration. The original title of the report has been retained in this paper.

A market analysis is a study of the field of distribution for a specific product and includes such factors as (1) the total potential market, (2) the past market (3) the present market (4) the future market (5) the factors which influence the market and (6) competition.

The market analysis covered in this study differs from those usually made in the commercial world in the following ways:

1. Personal services are being considered instead of material things.
2. Production requires from four to six years instead of a period of one hour to six months.
3. Production is not controlled by present market conditions.
4. The value of personal service when first sold is at a minimum value and increases with time whereas the value of material things is usually at a maximum initially and decreases thereafter.

The object of this analysis of Electrical Engineering graduates is threefold.

1. To determine the distribution of Electrical graduates in different fields.
2. To determine the relation between supply and demand of Electrical Engineering graduates.
3. To obtain an estimate of future openings for Electrical Engineering graduates.

A market analysis for graduates in Electrical Engineering should begin with a consideration of the potential openings for the

* Presented at the Conference on Electrical Engineering at the annual meeting of the S. P. E. E., at Montreal, June 26–28, 1930.

graduates. The potential field may be classified in many ways, three of which are as follows.—(*a*) Types of work, (*b*) major fields in which work may be performed and (*c*) leading employers of Electrical Engineering graduates.

The various types of work may be listed as follows:

CLASSIFICATION I

1. Consulting Engineering.
2. Research
   - (*a*) Pure science.
   - (*b*) Development.
3. Design Engineering.
4. Application Engineering.
5. Operating, Service, and Construction.
6. Commercial Engineering
   - (*a*) Sales.
   - (*b*) Office and management.
7. Manufacturing.
8. Miscellaneous work
   - (*a*) Teaching.
   - (*b*) Sales (non-electrical).
   - (*c*) Business.

The major fields in which work may be performed are:

CLASSIFICATION II

1. Electric Power Field
   - (*a*) Manufacturing.
   - (*b*) Public utilities.
2. Electrical Communication Field
   - (*a*) Telegraph.
   - (*b*) Telephone.
   - (*c*) Radio (commercial messages).
3. Vacuum Tube Applications
   - (*a*) Radio receivers.
   - (*b*) Talking movies.
4. Illumination Engineering. (This is a minor field judged by the number of openings.)
5. Non-engineering Field.

The leading Employers of Electrical Engineering graduates are given in the following classification:

CLASSIFICATION III

1. Electrical Manufacturers
   - (*a*) Power.

(*b*) Telephone.
(*c*) Radio.
(*d*) Illumination.

2. Communication Companies
   (*a*) Management.
   (*b*) Research and development.
   (*c*) Telephone operating.
   (*d*) Long distance.
   (*e*) Radio transmitting companies.
   (*f*) Telegraph.
3. Central Stations. (Electric power public utilities.)
4. Miscellaneous
   (*a*) Railroads.
   (*b*) United States government.
   (*c*) Educational institutions (teaching).
   (*d*) Business.
   (*e*) Etc.

The specific market analysis in this paper is being limited to graduates who complete their college training each year. This limitation is justifiable because the opportunities for the inexperienced graduate should reflect the opportunities open to earlier graduates and show the interaction of the natural economic forces of supply and demand.

With the above limitation given to this market analysis, Classification III becomes of the greatest importance since it represents the direct outlet (market) for the yearly graduates in electrical engineering. And fortunately this market (the employer) is one which is willing to give data regarding its needs for the past, present, and future. While there are many concerns which employ Electrical Engineering graduates, there are a few of them which hire the bulk of all graduates and this likewise tends to simplify the analysis and make for more accurate results.

The present analysis contemplates a period of ten years—from 1925 to 1935 inclusive, with special emphasis upon the year 1930. The data for this study have been secured through questionnaires which were mailed to about 100 employers coming under Classification III. The questionnaires asked for the following information:

1925 E.E. graduates employed during 1925 ————————
1929 E.E. graduates employed during 1929 ————————
1930 E.E. graduates employed during 1930 (estimated) ————
1935 E.E. graduates employed during 1935 (estimated) ————

The response to the questionnaire was highly satisfactory in the number of replies and the completeness of the replies.

It has been rather difficult to classify the information given by the questionnaires because some large companies with diversified products and activities come under two or more parts of Classification III, and yet the employment is made by a single department. Recent mergers in the electrical field have complicated the problem of classification still more. The classification which has been adopted for the purpose of this paper divides the field into five groups. The first four groups is given in Table I and the fifth in Table II. Table I contains almost all of the information provided by the questionnaires and covers the groups usually associated in the mind of the student with the field of Electrical Engineering.

TABLE I

Group	Number reporting	1925	1929	1930 (estimated)	1935 (estimated)
Electrical Manufacturers (Power equipment)	9	763	937	909	1038
Telephone—Telegraph—Radio (Commercial messages)—Manufacture, development, and operation	10	273	796	759	939
Applications of Vacuum Tube (Vacuum tube and radio—research, development, and manufacture)	4	15	129	167	283
Central Stations (Public utility)	35	225	274	323	416
Total	58	1276	2136	2158	2676

The data given in Table I have been plotted in the curves of Fig. 1. In studying these curves one should remember first that this distribution applies to the college graduates at the time they leave college and that it is not the distribution of Electrical Engineering graduates at a later period and second that the part of the curve covering the future represents the opinions of men in the personnel departments of industry. The electrical manufacturers of power equipment employ the largest number of E.E. graduates with the general communication group coming next. This general communication group covers the Western Union, Postal Telegraph, the Bell System, The International Telephone and Telegraph Company, The Radio Corporation of America and a number of independent telephone manufacturing and operating companies. This group has had a rapid growth in the past five years which has been reflected in the openings for college graduates in Elec-

trical Engineering. The group styled Vacuum Tube Applications covers general vacuum tube and radio applications outside of the general communication group. It is a group which had its origin about five years ago. It is interesting to note that the slope of the curves for all four groups for the next five years is very nearly the same.

The Electrical Manufacturing Group and the Central Station Group deal in power equipment and production and hence have certain things in common and might be classed together. Likewise the General Communication Group and the Vacuum Tube Application Group have certain elements that are alike and might be classed together. If such unions of these four groups be made the power group constitutes approximately 58 per cent. and the communication group 42 per cent. of the number represented on Fig. 1.

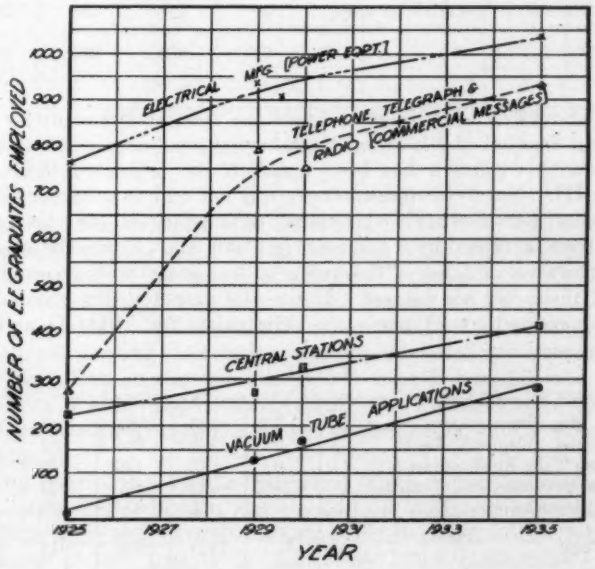

FIG. 1

The questionnaire did not and could not cover a large group of miscellaneous outlets for the Electrical Engineering graduates. An attempt to cover these outlets has been made in Table II. Those figures covered by an asterisk were obtained by questionnaire, the others are intelligent guesses of the speaker which were

checked and modified by intelligent guesses from others. The intelligent guesses have been substantiated in part by replies to questionnaires from railroads and by many contacts in placement work.

TABLE II

	1925	1929	1930	1935
Railroads	20	30	30	40
Civil Service	*3	*20	25	35
Army and Navy	*2	* 0	0	0
Illumination	10	15	15	20
Aviation	0	10	10	10
Auto industry	25	30	20	30
Teaching	125	150	150	150
Business (Misc.)	150	250	250	300
Agriculture	15	15	15	15
Remain in college (for advance work)	100	150	150	200
Total	450	670	665	800

It should be of interest to know the relation between the supply and demand of Electrical Engineering graduates. An attempt to show this relation has been made in the estimated figures of Table III. Since the questionnaire was not sent to numerous small electrical manufacturers the actual data collected for this group have been increased by 5 per cent. in Table III. Similarly only the larger central stations of the public utility group were covered and all of these did not answer. Hence the data for this group have been increased by 25 per cent. The totals for Table II and III

TABLE III

Elect. Mfg. (Power equip.)	+ 5%	800	984	955	1090
Telephone, Telegraph, Radio	0	273	796	759	939
Vacuum Tube Applications	0	15	129	167	283
Central Stations (Public utility)	+25%	283	342	403	520
Miscellaneous Group, Table II		450	670	665	800
Total		1821	2921	2949	3632

have been plotted in Fig. 2. A third curve in Fig. 2 shows the number of Electrical Engineering graduates for each year since 1921 as given by the United States Office of Education and by surveys of some of the largest electrical manufacturers.

The curve covering Table III reaches close to the curve for the number of graduates for the year 1929. And it is a well known

fact that the demand for electrical Engineering graduates in 1929 exceeded the supply. Thus it would seem that the assumptions of Table II (made before Fig. 2 was considered) must be too con-

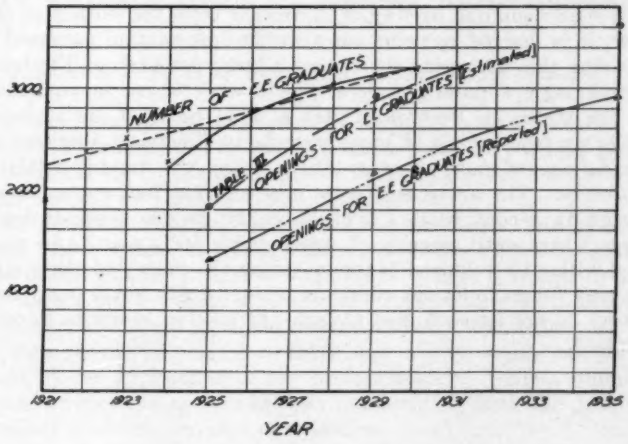

FIG. 2

servative. The fact that the difference between the opening and the number of graduates in 1925 seem to be greater than in 1929 may be explained by a lack of adequate personnel records at the earlier date. The dotted line for the number of Electrical Engineering graduates indicates the trend over the past nine year period. The curves showing the relation between supply of and demand for Electrical Engineering graduates are nearly parallel and thus indicate a healthy and desirable condition—sufficient openings for the capable college graduate and enough men to fill the vacancies in industry.

The distribution of the Electrical Engineering graduates has been considered to be that static condition which exists during the first year after graduation. We may be interested in the dynamic condition or distribution a few years after graduation. This future distribution may be estimated by a consideration of probable future shifts. Thus the electrical manufacturers give statements from time to time of the percentage of college graduates who remain with them permanently. The percentage is usually 60 to 65. A large part of those who leave go to the central stations and the rest into miscellaneous types of work. A small part of those who go into the general communication field join the central sta-

tion or miscellaneous group. After these shifts have taken place one should find approximately 25 per cent. of the college graduates in each of the four main groups, viz: the electrical manufacturer, communications, central station, and miscellaneous.

In conclusion and by way of digression from the subject of this paper, it is desired to point out that the information gathered in preparing this discussion shows that a large per cent. of Electrical Engineering graduates go into a type of work where vacuum tubes and the theory of electronics play a large part. I am seriously wondering whether all of our curricula in Electrical Engineering provide one of more courses which cover the fundamentals of electronics. The art is relatively new and has had enormous expansion in recent years. I plead guilty as one representing a college where until recently, it was possible for a man to be graduated without a required course covering the theory of electronics. It is easy for us to let our curricula become dusty but it is my hope that we do not let such dust obscure the need of revisions to cover this field.

THE DEVELOPMENT OF BRIDGE CONSTRUCTION *

By PHILIP G. LAURSON

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Bridge construction is an ancient art but a modern science. As an art it developed slowly and in a limited way over a long period of historical time. Its development as a science has been brief in point of time but almost incredible in extent.

As an art alone it achieved many beautiful structures of a few types. As a science it achieved wonderful structures—strong and efficient but generally plain or even ugly. There is reason to hope that an era has begun in which bridge construction will unite the perfection of beauty attained in the fullest development of the art with the perfection of strength and utility which can be attained by the application of the perfect science. Such a union of art and science can achieve bridges which satisfy both the demands of utility and the cravings of esthetics.

It is not primarily of esthetics that I am to speak. My aim is to trace the development of bridge construction from the primitive inventions to the present high development—through the period of the art into the period of the science of structures and down to the present day.

Before we begin our journey through thirty and more centuries of time I propose to point out five great influences without which bridge construction would not have advanced to its present state. These influences were either inventions or discoveries (it matters not which) or the direct results of inventions and discoveries.

Primitive men did not need to invent simple slab and beam bridges. Fallen trees and natural stone slabs accidently formed small bridges which were improved and copied. In this manner stone bridges a few feet in span, and wooden bridges somewhat longer were made without invention and with little thought. Then some one, at some time (we care not who nor when) invented the arch and forthwith stone bridges with spans greater than the length of a single stone became a reality. This is the first of the great inventions.

Probably many centuries later, when men used wood-working tools, it was found that frames could be built of pieces of wood

* A lecture delivered before the Civil Engineering Session of the Summer School for Engineering Teachers, Yale University, July 9, 1930.

and that such frames could be made to span openings longer than the length of any stick in the frame. This (probably not the invention of any individual) was the second great invention. Its effect was important after the close of the "dark ages."

The third great invention had to do with materials instead of structural types. Processes for producing iron and steel in large quantities and at low cost revolutionized the art of bridge building. Gradually, between 1500 and 1800, cast iron was developed and cheapened. The names of Dudley and Darby are important in this development in connection with the use of coal for smelting and steam for operating the blast furnaces. Then, late in the 18th Century, Henry Cort was largely responsible for devising economical methods of puddling and rolling wrought iron and this metal also soon became available in quantities. Before 1860 Henry Bessemer invented the Bessemer process for steel production and shortly thereafter Sir William Siemens and P. and E. Martin developed the open hearth process for steel. Before Bessemer's invention steel had been a comparatively rare metal useful for blades and tools; after these inventions new materials were available for bridges.

The fourth great influence was an indirect one, but one which played an important part in the development of bridge construction. The rapid spread of railroads required the construction of bridges in incredibly large numbers. Furthermore, railroads were commercial ventures and were therefore expected to pay dividends. The bridges which carried them over the rivers had to be built at the lowest cost and in the least possible time. And in addition, the character of loading required strong and rigid bridges. This commercial development was an unprecedented stimulus to the construction of bridges.

The fifth great influence was the perfecting of the principles of stress analysis and design, making possible the scientific design of beams and trusses. While this did not come all at once, only a few decades elapsed from the time when bridges were designed purely by empirical methods to the time when almost exact calculations could be made for trusses and beams.

It will be helpful to keep these five great influences in mind as we follow the lines of progress in bridge building.

It seems that an historian must divide time into periods. For our purpose the time which has elapsed during the development of bridge building will be broken up into four periods. The first period begins as far back as you care to have it and extends to 1775; probably about thirty centuries will include most of what is historically known of the development up to this time. The second period extends for 1775 to 1850, three-quarters of a century.

The third period is the last half of the nineteenth century and the fourth period includes the twentieth century to the present time. I shall not undertake to look into the future.

Bridges before 1775.—Of all ancient peoples only the Romans participated to any great extent in the development of bridge construction. They were great colonizers, pushing their military roads into all parts of their known world. This required bridges. But above all they had a peculiar genius for building bridges and aqueducts. Many of these still stand intact after eighteen centuries and more. We must realize that those now standing are but a small

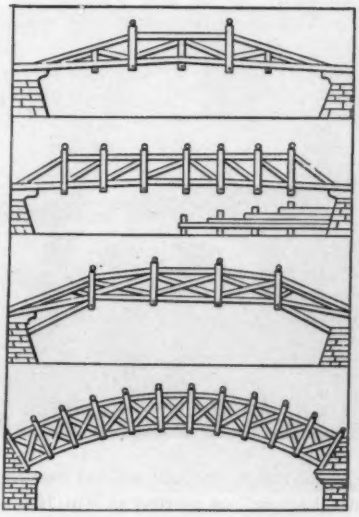

FIG. 1. Trusses Used by Palladio.

part of those built. Those still enduring are monumental structures. There were innumerable smaller utilitarian structures of wood and stone. Timber cleared from the rights-of-way of the straight Roman roads was more than ample for most of the bridges. Pile trestles were very common structures. Fire and decay have obliterated these and few were thought worthy of a place in written history. The Pons Sublicius (which simply means "the pile bridge") over the Tiber at Rome was built more than six centuries before Christ and endured for at least three centuries, carefully repaired by the chief priests. Julius Caesar, during his invasion of Germany, bridged the Rhine with a very creditable pile

trestle. It is far more important that he was a writer and gave us a careful description of this. The 1800-foot trestle was built in ten days with enemy forces threatening the builders; which is good evidence that such construction was common and that the workers were skilled in planning and executing this type of bridge.

Skipping centuries, let us next consider the work of an Italian architect, Andrea Palladio, born in 1518, who made drawings of wooden frames which he used in bridges and roofs. They differ little from some modern trusses. Here was one of the great inventions of bridge construction, making possible the construction of long spans from short pieces, and without the necessity of the substantial horizontal abutments required by arches.

FIG. 2. Ponte Molle, Rome, 109 B.C., restored (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of Wm. Helburn, Inc., publishers).

Two centuries later, near the close of this period, two Swiss carpenters, Ulric and Jean Grubenmann, became famous as builders of wooden bridges. Their masterpiece was a wooden bridge with a clear span of 390 feet—the longest wooden span ever built.

But the most important development during this period was that of the masonry arch. It began, probably more than 3000 years before Christ. I do not think it was suggested by the natural stone arches, as do so many writers. This invention was well within the ability of men of early civilizations. We know that by 578 B.C. the great main sewer of old Rome was built, with a diameter of eleven feet—a semi-circular arch with radial joints. This implies rather advanced knowledge and experience in this structural form. By 100 B.C. the Ponte Molle was built across the Tiber. This is a

splendid piece of engineering which has been somewhat restored during its life of twenty centuries. The necessity for maintaining high elevations where aqueducts crossed valleys resulted in magnificent structures. The Pont du Gard at Nîmes, in France, was built within a few years of the beginning of the Christian era. One cannot look at this aqueduct without feeling that the art of building bridges of stone was very close to its culmination while Christ was a young man in another Roman province. Within the first century the aqueduct at Segovia, in central Spain, was finished, and it is

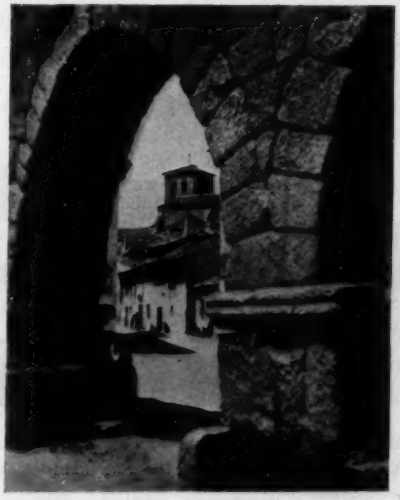

FIG. 3. Detail of Roman Aqueduct, Segovia, Spain, 98 A.D. (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of William Helburn, Inc., publishers).

still bringing cold water from the Sierra Fuenfria. It is nearly half a mile long and over 100 feet high. The stones are rough-hewn granite, laid up without mortar.

It hurts a Pontist (as W. Shaw Sparrow calls a devotee of bridges) to pass lightly over the lovely and picturesque bridges of the dark ages—bridges built with much feeling and skill, but without much science. Many of these were constructed in the spirit of public service to travellers and pilgrims. Some were commercial ventures and some were built with military needs in mind. One of the oldest existing medieval bridges is thought to have been built during the reign of Charlemagne, in the eighth century.

About 1177 there came into being a religious order in France—"The Brothers of the Bridge." Its purpose was to aid travellers and pilgrims by building bridges. During the three centuries of its existence many fine bridges were built by its members. The best known of these is the bridge over the Rhone at Avignon, a few miles from the Pont du Gard. It is often called the bridge of St. Benezet after its builder, who died before its completion and is buried in the chapel over one of the piers. There were probably twenty-one arches, the longest about 110 feet, of which only four remain. Because of its interesting history and tradition, writers have described this bridge at great length, although there are other bridges equally remarkable and equally old.

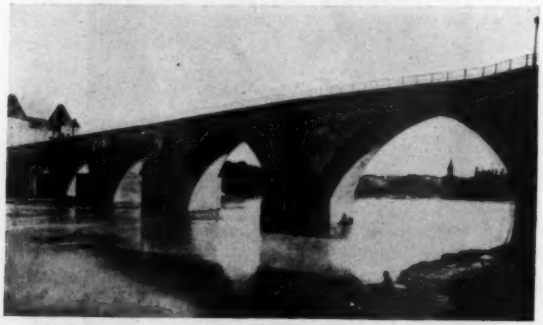

FIG. 4. Medieval Bridge, XIVth Century, Montauban, France (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of Wm. Helburn, Inc., publishers).

About the same time Peter Colechurch, a priest, made plans for a great bridge over the Thames at London. After 33 years of labor this was finished in 1209. The bridge was endowed by the people of England with money and lands and its history and tradition has filled books. After a life of nearly six and a quarter centuries it was replaced by the new London bridge, finished by Sir John Rennie in 1831. Though substantial and well founded on elm piles, the old London bridge was, in many respects, a poor piece of engineering. It has been called a "pierced dam" for the clear openings totalled only about one-third of the length.

Of the scores of important masonry bridges built during this period I can mention only two which are typical. The bridge crossing the Tarn at Montauban is an example of a splendid brick bridge. It was finished in 1335 after many years of work and a

century and more of talking. The arches are about 70 feet in span. The bricks used were several times as large as present-day bricks. In five years the bridge will have its 600th birthday, having safely survived only last spring another very serious flood of the temperamental Tarn River.

Gradually a new culture developed in Europe called the Renaissance. Architecture and bridge building were influenced as were all arts and industries. Contrast the sixteenth-century Ponte della Trinita at Florence with the bridges of Rome and the middle ages. The semi-circular arches have given place to delicate elliptical arches with small rise. Mouldings and ornament have been added. The whole effect is the resultant of perfect comprehension of esthetic laws and a high degree of skill in construction.

And so we come to the time of the American war for independence. The achievements of man in bridge construction up to this time have been small beam bridges of stone and timber, bold Roman arches, giving way to picturesque medieval bridges, and these in turn evolving into the esthetic refinement of the later Renaissance. Besides these, a few trusses have been constructed by builders without any knowledge of stresses or strength of materials. The materials of bridge building have been, up to this time, only wood, brick and stone.

Bridges from 1775 to 1850.—Let us see what the next three-quarters of a century accomplished. Newcomen and Watt had developed steam engines into fairly efficient and reliable sources of power. While this development went on Abraham Darby—father, son and grandson—owners of iron works at Coalbrookdale, England, had succeeded in using coal instead of charcoal for smelting iron and had applied the new "fire engine" for blowing, instead of the "water engines" commonly used. When the third Abraham Darby took over the iron works the traffic in coal, iron, brick and pottery had grown to such an extent that the ferry over the Severn was entirely inadequate. It was natural enough for Darby to decide to build a bridge. But we must regard it as somewhat remarkable that he decided to cast it in his foundry. This had never been done before! It was not a bridge of ten or twenty feet, but an arch bridge of 100 feet that Abraham Darby cast and erected where since the little town of Ironbridge has grown. It was not an imitation of a stone arch, nor a replica in iron of any wooden bridge. Here were entirely new forms for which only this new material could be used. I think you will agree that in 1779, when Darby had finished the first iron bridge in the world, a new period in bridge construction had begun. The bridge is still in service today after a century and a half.

Scores of cast-iron bridges were built in the hundred years following Darby's successful venture. Many of these were imitations of stone voussoir arches, such as the Sunderland Bridge over the Wear River in England. The design of this carried out the ideas of Thomas Paine—author and social reformer—and the arch was built partly from iron previously used by Paine in a model for a 400-foot bridge proposed by him for Philadelphia. Thomas Telford and John Rennie both built cast-iron bridges, Telford seriously proposing one with a span of 600 feet over the Thames at London.

FIG. 5. First Iron Bridge, 1779, Cast-iron Arch at Coalbrookdale.

The introduction of a new material is a significant step in bridge construction. We have seen how cast iron became available. In 1783, Henry Cort, a dealer in iron bolts and fittings for wooden ship building, invented grooved rolls and applied his invention to the rolling of wrought iron. The following year, 1784, he patented the method of refining known as puddling, which is still used in the making of wrought iron. These two inventions increased the production of wrought iron and greatly lowered its cost, making another material available for construction uses when the need for it should arise.

While cast-iron bridges were being built in Europe a remarkable development of wooden bridge construction was taking place in the United States. Highways were being extended at a remarkable rate and the growth of industries demanded more and better bridges. The logical material was wood, available in unlimited quantities and of the best quality.

The first long span wooden bridge in America was built in 1792 over the Connecticut River at Bellows Falls. It was designed by Col. Enoch Hale and had two spans of 175 feet each. It was of a type which (with many variations) was widely used in America during the period we are considering. This consisted of a curved arch rib with a trussed frame attached to it,—a highly indeterminate type. In fact, only by a thorough understanding of the principles of structures can indeterminateness be avoided and such knowledge did not exist at this time.

The same year (1792) Timothy Palmer built a bridge at Newburyport, Mass., with a span of 160 feet. From 1801 to 1805 he was building the "Permanent Bridge" in Philadelphia, with a span of 195 feet. Theodore Burr was another builder of long span wooden bridges. His best-known bridges were those at Waterford, Trenton, and Schenectady.

Some of the most remarkable American wooden bridges were built by Louis Wernwag. The "Colossus" Bridge over the Schuylkill River at Fairmount, his masterpiece, was finished in 1812 and had a clear span of 340 feet.

In 1820 a New Haven architect, Ithiel Town, invented and patented a new type of bridge—the Town Truss. His first bridge was built about two miles north of the center of New Haven, over the Mill River. Town's truss was strong and rigid, it exerted no horizontal thrusts on the abutments, and it could be manufactured out of sawn planks—greatly cheapening its construction. This was the first true truss in modern bridge construction and it greatly influenced later bridge building, a fact acknowledged both in Europe and in America.

In 1801 James Finley, of Fayette County, Pennsylvania, added another type of bridge to the existing modern bridges. This was the suspension bridge. It is true that there had been small suspension foot-walks built in the seventeen-hundreds, in which the floor followed the flexible curve of the chains. Finley, however, made the suspension bridge into a real bridge with level floor capable of supporting concentrated loads without undue deflection. An early drawing reveals all the elements of the modern suspension bridge. It shows at one end the roadway suspended from the backstays and at the other end the straight backstays and separately supported roadway. Finley patented this type in 1808. Thomas Pope carefully described it in his treatise on bridge architecture published in 1811.

The oldest American suspension bridge is the one at Newburyport, Mass., which was built in 1810 from Finley's design. The span is 244 feet, center to center of towers. In 1816 wire was first used in a small suspension bridge built for pedestrians by White

and Hazard, manufacturers of wire. The wire was ⅜-inch in diameter. The bridge was 408 feet long and a toll of one cent per person was charged.

FIG. 6. Old Chain Bridge, Newburyport, Mass., 1810. (Reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of William Helburn, Inc., publishers.)

Suspension bridges developed with great rapidity. In 1819 Thomas Telford began the construction of the Menai Straits Bridge.

FIG. 7. Menai Bridge, Wales, Thomas Telford, 1820–1826.

The span is 580 feet and there are four chains of flat, wrought iron bars, each 10 feet long, united by short links and 3-inch pins. The bridge is still in use. Telford built several other suspension bridges.

The suspension type of bridge is an excellent one for long spans and can be built very cheaply if the loads are moderate. By 1850 more than thirty suspension bridges had been built. In 1848 the bridge at Wheeling, West Virginia, with a span of 1,010 feet was built. Needless to say, this span far exceeded the span of any other type of bridge at that time. There were also about this time a good many failures which cannot be recounted here.

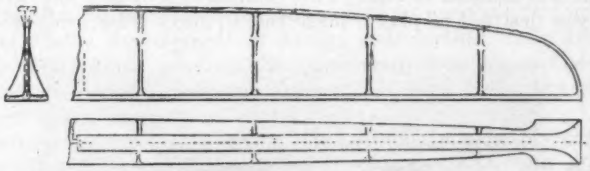

FIG. 8. Early Cast-iron Girder (from Encyclopedia Britannica, 1878).

The development of bridge construction might have run along at a slow and steady rate had it not been for the railroads. Since 1825 the demands of railroads have resulted in new types of bridges; larger, stronger, and more economical. Unfortunately many of these are needlessly ugly.

Stone and brick arches naturally met these needs excepting those of cheapness and speed of construction. Cast iron was immediately used, but before very long it was discovered that its brittleness made it unsatisfactory for railroad bridges.

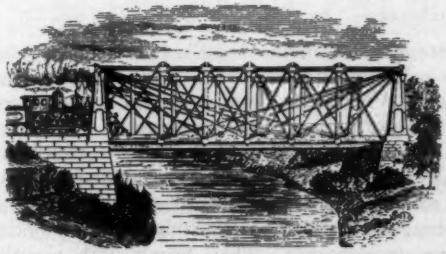

FIG. 9. Early Bollman Truss (from Mahan's "Civil Engineering").

Wooden trestles served admirably for some of the smaller bridges but the engineers who were called upon to build the bridges were driven to types that were new. The first iron railroad bridge was built on the Stockton and Darlington line in 1823 by George Stephenson. It was a very small trestle with lenticular trusses, without diagonals.

With an instinct for truss forms and by the aid of experiments, the railroad engineers invented more satisfactory types. In the United States, Wendell Bollman built bridges with the truss known by his name. These came into use about 1840 on the Baltimore and Ohio Railroad.

In 1840 Squire Whipple built a bowstring truss bridge with cast-iron top chords and wrought iron tension members, and in 1841 a patent was granted to him. This combination of cast and wrought iron was destined to play a large role in early truss bridges.

FIG. 10. Britannia Tubular Bridge, 1850 (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of William Helburn, Inc., publishers).

Robert Stephenson, in the 1840's, faced the necessity of a railroad bridge over the Menai Straits with the then enormous span of more than 400 feet He first turned to the cast-iron arch for a solution of his problem, but the Admiralty did not allow the encroachment on the headroom of the channel. Stephenson therefore turned boldly to a new type—the wrought-iron tubular bridge. Today it is almost impossible to appreciate the daring of this conception. Stephenson retained Fairbairn and Hodgkinson to carry out extensive experiments. They began with circular tubes and evolved the rectangular type with cellular top and bottom. The final experiments were on a model 75 feet between supports. Fairbairn was interested in iron ship building, and was familiar with riveted iron work. The tubes were built and successfully lifted into place, an achievement which, in one case, almost ended in disaster. By 1850 three tubular bridges were in use; the most important being the Britannia Bridge over the Menai Straits, having two spans of 460 feet each.

Not the least important developments of this period were the advances made in the theory of beams and trusses. The beam theory had been satisfactorily worked out by Navier about 1820. In 1847 Squire Whipple, in the United States, published a "Treatise on Bridge Building." This is now conceded to have been the first work correctly treating the analysis of stresses in trusses. Neither the theory of beams nor the theory of trusses were widely applied until after 1850.

The Period from 1850 to 1900.—And so we come to the third period of the development of bridge construction, from 1850 to 1900. During the previous 75 years many new types had been evolved and many successful bridges had been built, but mostly without scientific analysis.

During the fifty years of this half century the natural "survival of the fittest" narrowed the number of types to the few best adapted to the needs. Tubular bridges and cast-iron arches were built in this period, but became obsolete before it closed. The highly indeterminate types of trusses largely gave way to the simpler determinate types—even the continuous trusses becoming temporarily obsolete.

The period opens with but one small book correctly treating the stress analysis of trusses and closes with the subject well understood by the average civil engineer and taught in hundreds of schools. Other treatises followed close after Whipples', one by Haupt, independently written, appearing in 1851. The period opens with wrought iron as the principal material for bridges and closes with steel entirely supplanting it and alloy steels available.

Many stone arches were built in this period, but concrete became a rival of stone and reinforced concrete was developed, adding another material to those available for bridge construction.

Of the hundreds of important bridges only a few can be mentioned and these are not necessarily the greatest. At the beginning of this period plans were under way for the construction of the Newark Dyke Bridge to carry the Great Northern Railway over a branch of the Trent River in England. The designs were made by Charles Wild and the main spans were Warren trusses 240 feet in the clear. This was scientifically designed with cast-iron tubular compression members and wrought-iron tension members. Joseph Cubitt described this in the Proceedings of the Institution of Civil Engineers, and stated: "The parts are so proportioned, that when loaded with a weight equal to one ton per foot run, which considerably exceeds the weight of a train of the heaviest locomotive engines in use on the Great Northern, or on any other narrow gage *

* "Narrow gage" at this time in England meant 4 feet, 8½ inches. The "wide gage" was 7 feet.

line, no tensile or compressive strain on any part exceeds 10 tons per square inch of section." This bridge was finished in 1853, the

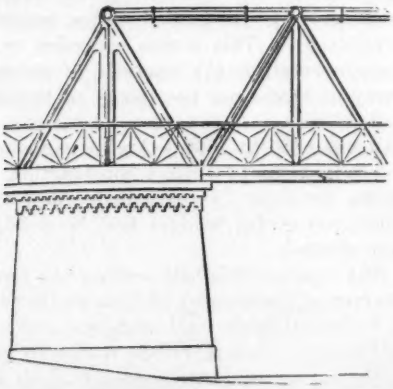

FIG. 11. Newark Dyke Bridge (from Encyclopedia Britannica).

first example of a type of truss that is still commonly used—the Warren truss, named after Captain Warren, an Englishman.

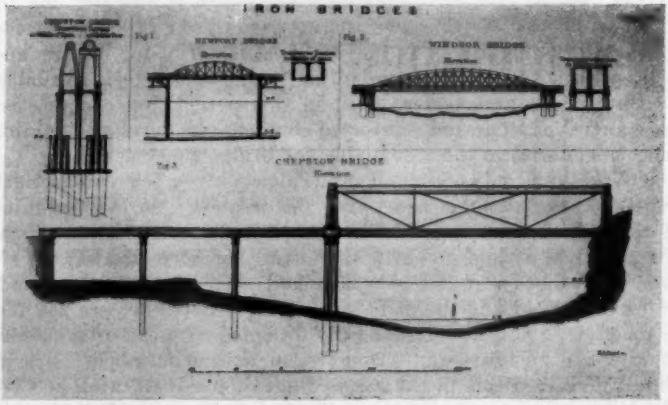

FIG. 12. Early Truss Bridges (about 1855, I. K. Brunel, Engineer (from "Life of Brunel")).

In America, Whipple adopted the type which bears his name. Diagonals crossed two panels, making correct stress computation

difficult. In 1852 one of these was built near Troy, New York. Many more were built before it became absolute.

Fink trusses followed soon after the Bollman trusses, the first large one being built in 1852 at Harpers Ferry. The span was 124 feet.

In England at this time, I. K. Brunel was groping for suitable types for long-span railroad bridges. He was a man of considerable originality though at times his judgment was not the best. By 1850 the Windsor Bridge had been finished with bowstring trusses, and in 1852 he finished the Chepstow Bridge, a through Pratt truss of 300 feet span. Its proportions and details are strange indeed. There are only three panels of 100 feet each, and there is a single tubular top chord serving for two trusses. This latter peculiarity he repeated in the Saltash Bridge, where the single top chord is a tube 16 feet, 9 inches broad and 12 feet, 3 inches high. This bridge

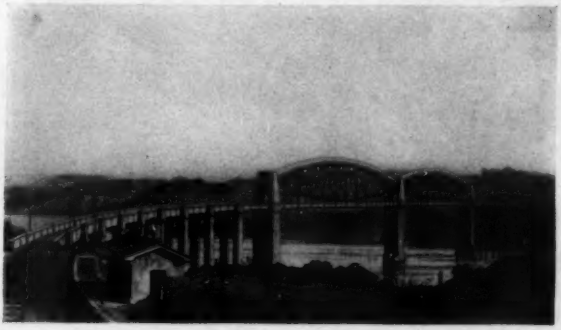

FIG. 13. Royal Albert Bridge, Saltash, I. K. Brunel, Engineer (from "Life of Brunel").

(opened by Prince Albert in 1859) is still in service. Probably Brunel thought that this arrangement was best and expected it to be generally used in the future, just as Stephenson believed that the tubular type of bridge was the last word in long span bridges.

By the beginning of this period the suspension bridge had been well developed. In 1854 John A. Roebling, a builder of experience, finished the first and only important railway suspension bridge at Niagara Falls. It was a double deck structure with a span of 821 feet between centers of towers—much the longest railway span at the time. There were four cables, each 10 inches in diameter. It served (with extensive repairs) until replaced by a steel arch in 1896.

The development of railroad truss bridges is too complex to treat in detail in a short talk. After 1860 bridge companies were formed, generally with the bridge engineers from railroads as their chief engineers. A pretty good picture of the status of truss bridge development can be had by looking at the advertisements appearing in old magazines. In one issue of the Railroad Gazette in 1875 seventeen different companies advertise nearly as many types of bridges. Of these only two types would be favorably considered today—the Pratt and the Warren. The Patapsco Bridge Company

FIG. 14. Roebling's Niagara River Railway Suspension Bridge.

(Wendell Bollman, Proprietor) displays the Bollman truss. The Louisville Bridge and Iron Company (Albert Fink, President) shows the Fink truss. A. J. Post is Engineer of the Watson Manufacturing Company, "Builders of Post's Patent Diagonal Truss Bridges of iron, wood, or wood and iron combined, for railroads, highways, roofs, turn-tables and general machine work." The Whipple truss is advertised by the American Bridge Company (not the present company of that name). Charles H. Parker is one of the proprietors and also Engineer of the National Bridge and Iron Works, displaying the Parker truss—the only one with curved top chord. J. H. Linville is president of the Keystone Bridge Company, which displays a swing bridge (Linville was the first to use wide, forged eyebars, 1861). The Baltimore Bridge Company, C. Shailer Smith, President and Chief Engineer, shows a subdivided Warren truss. Willard Pope is President and Engineer of the Detroit Bridge and Iron Works, displaying the Pratt truss.

Many wooden Howe Trusses were used for railroad bridges in this period. In Europe the lattice truss of wrought iron was very popular over a long period. A famous example is the lattice bridge

over the Rhine at Cologne, Germany, built in 1859, with 322-foot spans.

In 1876 C. Shailer Smith built the first important railway cantilever bridge—the Kentucky River "high" bridge, with three 375-foot spans. The advantage in erection of this type made it widely used from this time on.

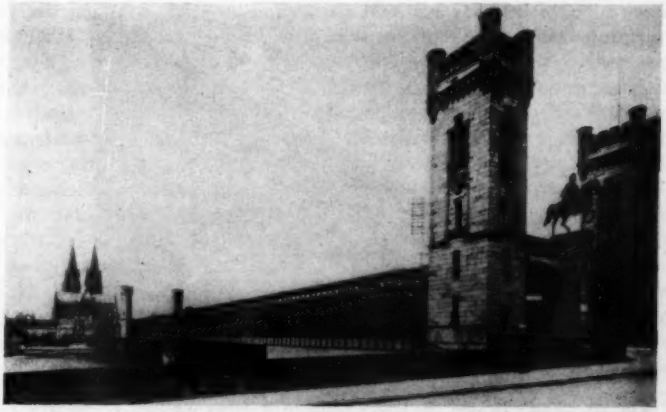

FIG. 15. Lattice Railroad Bridge, Cologne, 1859 (from Whitney's "Bridges").

During this half century there occurred two or three of those outstanding achievements that mark advances far beyond normal progress. James B. Eads built his great arch bridge over the Mississippi River at St. Louis between the years 1869 and 1874. The center span is 520 feet. The ribs are tubes of chrome steel—the first extensive use of steel in bridge building. It was erected by cantilevering from each pier, probably suggesting the advantages of cantilever bridges. Between the years 1869 and 1883 the Brooklyn suspension bridge was designed by John A. Roebling and built by his son, Washington Roebling. The span is 1595 feet, center to center of towers. Between the years 1882 and 1890 the Firth of Forth cantilever was built; Sir John Fowler and Sir Benjamin Baker, designers. No description of this bridge is needed. The main members are tubular—a boiler maker's job rather than a bridge fabrication job in the modern sense. The material was open-hearth steel. For 27 years its two spans of 1710 feet were the longest. The boldness of these three bridges cannot be realized at the present time. Each was of a magnitude far beyond anything before it. It must be granted that metal bridge construction was already in an advanced state to make such structures possible.

The closing years of the nineteenth century saw steel completely replace wrought iron and concrete become a rival of stone for all except the most expensive arch spans. Reinforced concrete was added to the materials available for bridge builders. A few, simple, rigid, well-established truss forms replaced the innumerable combinations devised at the beginning of the half century.

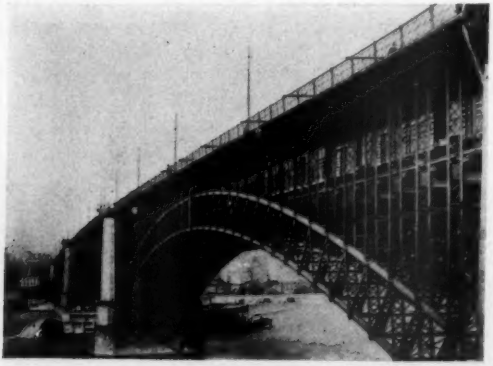

FIG. 16. Ead's Bridge, St. Louis, 1868–1874 (from Whitney's "Bridges").

Since 1900.—The development of bridge construction resembles the growth of a mighty tree. The roots go deeper and deeper and the branches spread wider and wider, and in each succeeding year increase in number. It becomes increasingly difficult to picture with any detail the later developments of bridge construction. Very sketchily have these developments been outlined up to the close of the nineteenth century.

Only a glance is possible at the developments of the twentieth century. New conditions exist. Financial resources are available for projects on a larger scale than ever before. The Firth of Forth bridge cost $16,000,000 and required eight years of time. The new Delaware River bridge cost something more than twice that amount of money, while the Hudson River Bridge may cost five times that amount.

But other resources are also available that were lacking in earlier times. Eminent engineers with long experience are on hand to design the bridges. Large bridge companies are ready to contract to carry out the plans. Under the chief engineers is a staff of highly competent assistant engineers, and a company of draftsmen well-trained in the work of preparing the actual plans. Ma-

terials of higher quality are available in unlimited amounts. Tests and researches are carried out before the work begins and as it progresses. The results are bridges which are bigger and safer than any that were built in earlier times.

A few of the advances that characterize the twentieth century bridge construction will be mentioned. Greater refinement in calculation, often including the calculating of secondary stresses due to rigid joints. These in many instances, are checked by field measurements with strain gages, and in some instances initial deformations have been given to members during erection to reduce secondary stresses under load. More exact methods are now used in the design of suspension bridges, eliminating previous false assumptions and approximations. Continuous and other indeterminate types are accurately designed, and in some types scientific *mechanical* analysis is used.

In actual construction greater rigidity and more substantial details are the order of the day. At the present time a large part of nearly every great structure is alloy steel or heat treated carbon steel. This permits increased unit stresses without sacrifice of safety. Without this economy of weight our largest spans would not be feasible.

There are still many open questions upon which engineers are divided. And, after all, as Professor Swain used to say, the big question for the bridge engineer to settle is not "how to build a bridge," but "whether to build a bridge." The success of modern tunnels has made this question even more acute.

The twentieth century has produced the greatest bridges of every type excepting those which have become obsolete, such as the tubular girders and wooden arches. There is time for the mention of only a few. The Frederic August Bridge at Plauen, Saxony, with a span of 295 feet is the longest stone arch. It represents a gain of 44 feet in five centuries.

Among the many long reinforced concrete arches is one at Saint Pierre du Vauvray, France, with a span of 430 feet. At Brest there is nearing completion a reinforced concrete arch of 612 feet.

The largest cantilever bridge is the Quebec Bridge with its span of 1800 feet. This span is about 5 per cent. greater than the span of the Firth of Forth Bridge, which was finished 27 years earlier.

Many large continuous truss bridges have been built since 1915. The largest is the Sciotoville Bridge, with a truss 1550 feet long, resting on three supports. This was completed in 1916. In the same year the longest simple truss was finished. This is in the Metropolis bridge over the Ohio river, with a span of 720 feet.

While the largest and heaviest arch in service today is that of

the Hell Gate Bridge, there are two nearing completion with much longer spans. These are the Kill von Kull bridge, with a span of

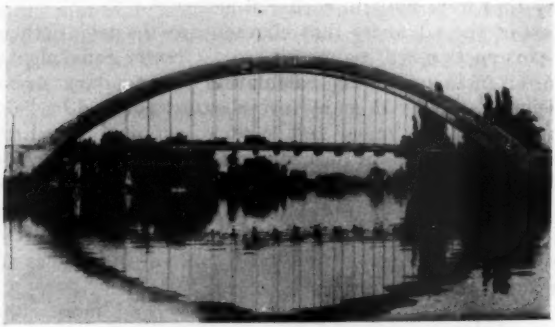

FIG. 17. Highway Bridge at Saint-Pierre-du-Vauvray, France, 430 foot span (from Whitney's "Bridges").

1652 feet center to center of pins, and the Sidney, Australia, arch, with a corresponding span of 1650 feet. There is also under con-

FIG. 18. Hellgate Bridge, 1916 (reproduced from Wilbur J. Watson's "Bridge Architecture," by courtesy of William Helburn, Inc., publishers).

struction the Hudson River suspension bridge, the span of which (3500 feet) nearly doubles that of the largest existing suspension bridge.

The Firth of Forth bridge (begun fifty years ago), the still older Brooklyn bridge and the Eads Bridge are evidence enough that the twentieth century holds no monopoly on creditable achievement. Great progress has been made but the pioneers who designed

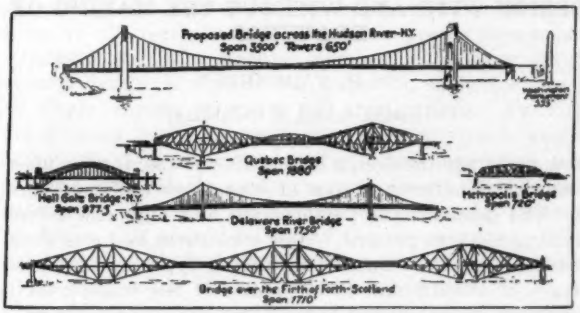

FIG. 19. Diagrammatic View of Long-Span Bridges, drawn to the same scale.

and built the great bridges of earlier times were surely great engineers. Let this generation give them the credit and praise which, it is to be hoped, the generations to come will be ready to award to the bridge builders of today.

THE RELATIVE VALUE OF THE TEACHING OF MACHINE DESIGN WITH AND WITHOUT THE MAKING OF DRAWINGS

By W. V. DUNKIN *

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A few years ago the design of machinery was, for the most part, of an empirical nature. Types of structures and machines were simple. The demands for performance and high efficiencies were less exacting than at present. New structures and machines were fashioned to a great extent after existing types and models. The advantages of the division of labor and of the transfer of intelligence were but vaguely realized. Emphasis was placed on "what had been done," rather than on adaptability and originality. The writer well remembers the injunction of his professor in machine design which was in substance: 'First get all the catalogues bearing on your design, proportion the parts of your machine after the parts of the old machines, using such devices and arrangements, found in the catalogue, as may seem to meet or suit your requirements.' This procedure is not without merit today in commercial design but to make use of this principle, now, to any great extent, in machine design classes, would defeat the very object for which courses in machine design are given. On the walls of the drawing room of a certain technical school, hangs, at present, assembly drawings of two locomotives. These drawings were made in the late eighties, and in size are, each, about five feet long by three feet wide. The locomotives were designed(?) from pictures in a catalogue. These drawings include about all the work in machine design of the senior class of that time. Machine design of that period had not yet been placed on a scientific basis. Known fundamentals were few. Under such conditions, therefore, the drawing board was about the only medium through which machine design could be imparted to the student.

To-day the requirements in engineering education seem to point, more and more, toward the mastering of principles and fundamentals, rather than specializing too highly in technical details. It could hardly be otherwise with the time now available in the four years of a college course. If a student obtains a fairly good

* Presented at the Conference on Machine Design at the S. P. E. E. meeting in Montreal, June 26–28, 1930.

knowledge of certain fundamentals and some training in their application, he has accomplished about all that may be reasonably expected of him within the four year period of an engineering course.

One of the objects of a course in machine design is to furnish an opportunity, for the student to apply the fundamentals and principles, in the mechanics, to determine proper dimensions and other characteristics of a machine member. An important part in preliminary design is discovering paths of characteristic points, relative displacements, velocities and accelerations. For this purpose the drawing board affords a convenient approach, and should by all means be used whenever possible. This suggestion, however, applies more particularly to commercial design than to ordinary student work. The work in kinematics, generally precedes the work in design. It should be one of the requirements. The time element prevents a student from making other than a more or less elementary application of the kinematics to design.

A thorough and comprehensive course in theoretical mechanics and in the strength of materials should precede the work in machine design. The student will not, in general, bring from his class work in mechanics to his class work in machine design, many of the principles of mechanics. Unfortunately, it seems, too much emphasis is placed by instructors on periodic quizzes and examinations. The student, therefore, soon arrives at the conclusion that once having passed the requirements, set up by the authorities, regarding grades, he may with propriety feel no further concern about work thus passed. If the student, in some manner, could be brought to realize the importance of mastering fundamentals for use in his life work, rather than for the purpose of passing a final examination, such examinations would be stripped of some of their unpopularity, better records would be made, and the student will have obtained, upon graduation, the highest of values, because of his work in the college class room. Outside of an improved attitude toward his work and better methods of study, the instructor may expect to find little else brought over into his design classes from previous courses. It would seem urgent, therefore, that the instructor should continually remind his students in design work of the basic principles in the mechanics and of their application as progress is made in the design work.

If, then, the purpose of machine design, in a college course, is to provide opportunity for the practical application of the mechanics to designing machinery either as a basis for a profession or for mental training only, it would seem wise to use all the available time for discussion, investigation and problem work in design, covering as wide a range in the mechanics as is possible. The grow-

ing complexity of machinery, to-day, and the higher efficiencies desired, as compared with machines of a few years ago, make it imperative that the designer of the present, have not only a working familiarity with a good hand book (which, if wisely used is a most valuable aid) but also an intelligent appreciation, familiarity and working knowledge of a wide variety of subjects. Accelerations, stresses in rotating parts, stresses due to vibration, elasticity, curved beams, welding and other subjects, must receive consideration by the designer of to-day. A generation ago these subjects may or may not have been given attention in design. To-day, however, these subjects in part or as a whole, are important considerations in economic and efficient designs. Evidently the methods applicable on the drawing board do not lend themselves easily to obtaining mastery; an intensive training and a working familiarity with the above subjects. A careful study of these subjects, from a good text book, under capable instruction, together with the solution of many, *many* practical problems and the making of careful free hand sketches, would appear to have far greater value.

To-day, industry is inclined to separate very markedly, the two functions, design, and drafting. A few years ago, technique, in drafting, was an objective in design. Now, the designer makes his sketches, and applying his fundamentals, determines important dimensions along with other characteristics of his machine or one of the parts. The sketches may then be turned over to a draftsman, who will make a scale drawing from which certain, more or less minor, dimensions may be determined. The designer will supervise the development of the drawing and may suggest changes in design, form, arrangement or method as a result of seeing the machine in a true relation to dimensions. Sometimes the designer may be his own draftsman, but designing and drafting are essentially separate functions.

The use of the drawing board is, of course, a most valuable aid to design in commercial work. However, most engineering students have obtained a fairly good technique in drafting by the beginning of their senior year. It is, therefore, a poor use of the student's time to have him work on the drafting board in order that a slightly better technique may be obtained. This technique may be secured easily, and in a brief time after graduation.

It would seem, therefore, that a student in machine design should be given every opportunity to secure a mastery of the fundamentals and principles in the science, and next, be required to work many problems, whose solution require the application of these fundamentals and principles; and lastly, be required to spend a minimum of time on "lay out" work.

THE DEVELOPMENT OF ENGINEERING MECHANICS

By JASPER O. DRAFFIN

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The ordinary undergraduate course in mechanics is built around basic principles which are few in number but which are extremely important. In presenting this science to the student the teacher should keep in mind the principles as the nucleus of a broad outline or background of the subject and fit the details into their proper place in the scheme. It is sometimes convenient to distinguish between the principles themselves and the tools used in applying the principles to practical problems.

The *tools* used both in analysis and in application are mathematics, graphical and algebraical. In discussing them and the men who are mainly responsible for their development, reference will be made to those men who have either originated or made significant contributions to engineering mathematics.

The first of these is Euclid (330–275 B.C.). Little is known of the personal life of this man but he prepared a treatise on plane and solid geometry, the twelve books of Euclid, which has been the foundation of our mathematical reasoning since that time. From a few axioms (as Euclid and earlier generations called them), postulates, and definitions was built up a complete set of proofs for numerous propositions. It seems probable that he merely compiled the material from various sources but, if so, the editing was done very carefully. In the same general period with Euclid is Hipparchus, a Greek astronomer of about 140 B.C. He is credited with having invented trigonometry and working out what is supposed to have been the first table of trigonometric functions.

After a lapse of about nineteen hundred years another man came on the scene of engineering mathematics. This was John Napier of Merchiston (1550–1617), a Scotchman who published his invention of logarithms in 1614. With him must be placed the Englishman, Henry Briggs (1561–1631), who made logarithms a really usable tool for engineering work by devising the common system of logarithms to replace or supplement those calculated from the Naperian base. The amount of labor which these men have saved engineers and scientists, especially through the graphical use of logarithms, *i.e.*, the slide rule, is almost incalculable. If we but consider that the gap between the invention of trigonometry

and that of logarithms is about the same in time as that between the destruction of Carthage and the Pilgrims landing at Plymouth it may serve to show the lack of mathematical accomplishment during the middle ages.

Our attention is next attracted to René Descartes (1596–1650), the great French philosopher who invented analytical geometry. It is probable that today only a relatively few people would have the patience to interpret his exposition of the subject because Descartes' presentation would hardly be called popular in this day of appeal to the eye and ear rather than to the reason. But a few rare minds analyzed Descartes' work and expressed it in a manner more readily understood than his own presentation of it and thus was born and grew that great tool of mathematics.

It is difficult to select any one individual who contributed so basically to algebra as applied to engineering that he can be given special mention. Yet, it seems that the Englishman John Wallis (1616–1703) is such a man. Previous to his writings the relationship between a number of quantities was expressed as a proportion or ratio but Wallis expressed the relationship between quantities in a form similar to the familiar equation we have today. While many may regret the too unthinking application of formulas, their proper use has made computation much simpler than it used to be. In fact without formulas it is difficult to understand how the multitudinous computations of engineering could be made.

While William Penn colonized Pennsylvania, two men, the Englishman Sir Isaac Newton (1642–1727), and the German G. W. Leibnitz (1646–1716), labored, achieved, and later wrangled with each other. For to each of these men came the thought that flux or change might be expressed mathematically and this idea grew under their skillful hands into that mightiest tool of the engineer and scientist, the differential and integral calculus. So accustomed to its use are we that it is rather difficult for us to appreciate the fact that calculus has not always been a ready instrument for the hand of man, however unskillfully some of us may use it.

The latest addition to our tools in mechanics is graphics or graphical analysis. The basic idea in graphics goes back to Stevinus who introduced the notion of vectors or the representation of a force by a directed line. Culmann (1821–1881) devised the string polygon as a working method for the solution of force systems and James C. Maxwell (1831–1879), in 1864, extended the application of the equilibrium polygon by bringing the separate polygons needed for each joint of a truss into a single diagram for the whole truss.

Before much progress can be made in arranging a method for the application of the principles of mechanics there must be some

scheme of reference points or a system of coördinates. An arrangement which allows a force or other vector quantity to be broken into parts, or a complicated motion into simpler parts, permits the handling of each element separately and thus facilitates the analysis of the force system. Of course these ideas were in the minds of many of the earlier workers, such as Stevinus, Galilei, Newton and others, but Euler (1707–1783) seems to have been the first to resolve formally a force into its components. He did this in the case of curvilinear motion by resolving a force into tangential and normal components in 1736 in his "Mechanica sive Motus Scientia Analytice." The next step was taken by Maclaurin in 1742 when, for the first time, he resolved a force into x and y components. This apparently fixed the mold for the future use of coördinates. In 1726 Daniel Bernoulli (1700–1782) fashioned a powerful tool for the study of motion when he resolved plane motion into a rotation and a translation and dealt with each separately.

We turn now to the *principles* of mechanics and their originators. First, of course, is Archimedes (287–212 B.C.), that Sicilian genius who was really a mechanical engineer at heart but who would have scorned such a designation because of the spirit of the times. He discovered some of the principles of hydrostatics and laid the foundation of our knowledge of mechanics. His system was mainly one of statics and it was founded on the *law of the lever*. This of course logically includes the topic of centroids, since the latter is merely a particular example of moments. The law of the lever or the moment of a force persisted as the principal mode of thought in mechanics for nearly nineteen hundred years. It is remarkable that the beginnings of mechanics should be so close to those of mathematics and that both of these should lie dormant for a long period and then awaken at the same time, statics in 1586 and logarithms in 1614, and march along together. It is true that the artist Leonardo da Vinci (1452–1519), a century earlier, showed a knowledge of a number of cases of statics but it is a long step from a few scattered ideas to a systematic and logical arrangement of principles into a single unit and therefore the ideas of da Vinci cannot be considered as a significant advance.

After Archimedes the scene of the next forward movement in statics was in Holland in 1586 when the Flemish writer Simon Stevinus (frequently written Stevin) (1548–1620) presented his famous work on statics entitled "De Beghinseln der Weeghconst" (Principles of Equilibrium) which was translated into Latin in 1608 and published as a part of his collected works entitled *Hypomnemata Mathematica*, and translated into French in 1634. Stevinus used the *inclined plane* or wedge as the basis of his statics

and developed its use to a remarkable degree. Reasoning from the readily accepted proposition that an endless chain hung over a triangular prism with the lower edge horizontal would not slide either way, he reached correct conclusions regarding the equilibrium of bodies on inclined planes. Though Stevinus used the principle of the parallelogram of forces, he did not expressly formulate a statement of the principle. He was, as previously noted, the first to represent forces by means of lines, *i.e.*, vectors, and was the first to introduce decimal fractions into regular use. He was a military engineer of considerable ability, an inventor, and an influence in promoting the improvement of the methods of public accounting.

Thus forces and their manifestations were presented from two different points of view by Archimedes and Stevinus, the earlier presentation being that of the tendency of forces to cause (or hinder) rotation and the later one that of the tendency of forces to cause or hinder translation. But as yet each problem which arose was dealt with separately; generalizing about forces and thus making the laws useful in a large number of cases had not yet been done in any comprehensive way. Machines and structures had not yet become complicated and therefore the application of known principles had not been extended very greatly.

The work of Stevinus though highly original did not exert a great influence during the life of the author partly because the time for his work was not ripe. A century later, in that period when interest in mechanics was much more intense under the influence of Huygens, Newton and others, Pierre Varignon (1654–1722) wrote a book on mechanics. His book contained little that was original in principle, being based on Stevinus' work, but he arranged and systematized statics into virtually the form it has to-day. The reader of Varignon is impressed, particularly by the diagrams, that he was interested in the applications of mechanics rather than in the abstractions. He added one important idea, viz., the *principle of moments,* or Varignon's Theorem as it is sometimes called. It is merely an extension of the principle of the parallelogram of forces to the moment of these forces. This idea, the principle of moments, was presented by Varignon in 1687 and also presented in the same year, but independently, by Bernard Lamy (1640–1715). Later, in 1818, Louis Poinset (1777–1859) added to our store of knowledge of moments or rotation by bringing out the theory of couples and their transformations.

Yet with all of the theory which had been evolved there was, a century ago, in some cases, a paucity of knowledge of application. Though Varignon showed plainly in 1687 the methods of vectorial addition of forces and the conditions which governed the equilib-

rium of a number of concurrent forces, there seems to have been no adequate analysis of a truss until Squire Whipple (1804–1881), of Albany, N. Y., in the early part of 1847, published a pamphlet giving an *analysis of trusses.* This pamphlet, of which only fifty or sixty copies were distributed, was supplemented by a second part and in the latter part of the year 1847 the two "Essays" were published as the first edition of a book, small in size, bearing the descriptive title "A Work on Bridge Building consisting of Two Essays, the One Elementary and General, the Other giving Original Plans, and Practical Details for Iron and Wooden Bridges." Whipple conceived the idea of taking each point where the truss members intersected (a joint) and by considering that point as being in equilibrium he was able to compute the stress in the intersecting members, surely a simple and easy procedure. August Ritter of Germany completed the simpler applications of statics in 1856 when he extended the methods of truss analysis by introducing the "method of sections" which is merely a case of the equilibrium of coplanar non-concurrent forces.

What of the science of moving bodies, kinetics? The number of people who have added to the sum total of our information on kinetics is large and yet there are a few men who stand head and shoulders above all others as the founders and discoverers of great principles. The first of these is Galilei (1564–1642) who founded the subject of kinetics. Galilei was not content to accept the current ideas of his day and so he studied, experimentally as well as analytically, the *motion of a particle.* From him the world gained its first real knowledge about the way a particle moves.

The knowledge of motion which Galilei inherited from the past was practically worthless. The Aristotelian view was that heavy bodies fell faster than light ones and they did so because all things occupied a prescribed place in the universe and naturally each body or particle took the place which belonged to it; the mechanics of that time was a species of metaphysics. Now Galilei did not inquire *why* bodies moved but *how* they moved. He says "The present does not seem to be the proper time to investigate the cause of the acceleration of natural motion . . ." and then follows this by saying "At present it is the purpose . . . to investigate and to demonstrate some of the properties of accelerated motion. . . ."* Galilei determined experimentally the laws which govern the motion of falling bodies and of projectiles and therefore his mechanics was mainly that of kinematics since he emphasized the acceleration rather than the forces which caused acceleration or the properties of the body which was accelerated. He experimented with balls

* Dialogues Concerning Two New Sciences, trans. by Henry Crew and Alfonso de Salvia, p. 166, Macmillan, New York.

rolling down grooves in an inclined plane and measured the time by weighing the amount of water which flowed from an orifice under a nearly constant head. Two items of extreme importance are found in his work; first, the contribution which he made to the knowledge of the laws governing the action of a particle and, second, the subjection of mechanical principles to experimental proof.

The prophetic mantle of Galilei was put aside to be laid later upon the shoulders of Christian Huygens (1629–1695), the Dutchman who added to the work of Galilei about thirty years after his death by bringing out the essential facts concerning the *motion of a rigid body.* He solved the problem of the center of oscillation by means of the principle which he set forth that the center of gravity of a system of particles would rise as high as the point from which it fell, and he introduced the concept of work and energy into mechanics. The pendulum clocks of to-day are based upon the work done by Huygens over two hundred and fifty years ago. There is a difference of opinion among authorities as to whether or not he had a clear understanding of mass but, be that as it may, he is the second great figure to appear in kinetics.

It is unnecessary to say much about Newton who in 1687 gave to the world his *Philosophiæ Naturalis Principia Mathematica;* his mind is one of the greatest of all time. Rather curiously the demonstrations and analyses in this monumental book were all geometrical though his work on the calculus was complete before the Principia was written. In this treatise the special cases treated by others are seen to be but shoots from the main stem, which main stem is undergirded by his "Three Laws of Motion." What powerful tools these generalizations of the laws of motion are! Newton was the first to present clearly the *notion of force* as it is held to-day and he clarified and crystallized beyond all dispute the *concept of mass.* Even if Einstein does modify our conception of the laws which govern the universe it still will hardly affect the applicability of "Newton's Laws" to the problems of engineering mechanics.

The motion of a body may be expressed in different ways. Galilei and Newton presented their ideas in terms of force while Huygens used the concept of energy. Since the relations existing between force, velocity, space, and time were very imperfectly understood by the average student, the subject of kinetics was much confused in the early part of the eighteenth century because of these two ways of expressing or describing motion. Two factions, one the followers of Descartes and the other of Leibnitz, maintained for years a dispute over the proper measure of the "force of a body in motion"; the "Cartesians", as they were

called, claimed that the force varied as the first power of the velocity (mv) while the adherents of Leibnitz claimed that the force varied as the second power of the velocity (mv^2). This confusion was dispelled forever by the Frenchman D'Alembert (1717–1783) when he clearly showed in the preface to his "Traité de Dynamique," 1743, that force did not reside *in* a moving body but was related to the difficulty of *stopping* a moving body and that it (force) was the measure of the amount of obstacle or impediment which the moving body might overcome. Thus he showed that the velocity of a body, under a constant force, varies as the first power of the velocity with respect to time, *momentum*, and as the second power with respect to distance, *kinetic energy*. This clear statement settled the dispute between the two factions and brought order out of chaos. D'Alembert evolved no new principles but made two great advances in kinetics. He showed that the sum of the eternal forces in a body is equal to zero, and may therefore be neglected, and, by the introduction of a reversed effective force, which is simply the application of the third law of motion, he reduced kinetics to statics. His great contributions were therefore the reduction of the kinetics problem to a simpler one of statics and the clarification of the confusion between energy and momentum. Our present treatment of kinetics is essentially that of D'Alembert; he helped to make kinetics an engineering tool.

One more principle or concept should be mentioned, even though it is usually omitted in the undergraduate course, that of *virtual work*. This was presented by the Swiss mathematician John Bernoulli (1667–1748) and later expanded into an elegant and comprehensive system by the Italian mathematician, L. J. Lagrange (1732–1813). In this system analytical mechanics has been brought to its highest state of perfection but not every engineer has the mathematical ability to handle its abstractions. Michael Pupin in his "From Immigrant to Inventor" pays high tribute to the latent power in Lagrange's "Méchanique Analytique."

Thus far we have come. The great *principles* which govern the motion and equilibrium of bodies in engineering work are well known. But the ramifications of the *applications* of these general principles are by no means all known. New applications are being made day by day, as, for instance, in statics the forces (stresses) acting in thin plates, and in kinetics the forces produced by vibration. Great laws are general and abstract but their application is specific and concrete. Surely we shall continue to have D'Alemberts, Huygens and Varignons who will extend the boundaries of our knowledge of mechanics and make the applications which are needed in our complex engineering problems.

AERIAL PHOTO SURVEYING AND MAPPING *

By S. D. SARASON

Professor of Civil Engineering, Syracuse University

Very few of our schools include Photographic Surveying in their Civil Engineering curriculum, and a still smaller number have attempted to teach Aerial Photographic Surveying.

Terrestrial Photo Surveying with a Photo Theodolite has been practiced to a limited extent for many years. There is included in the 1897 Report of the U. S. Coast and Geodetic Survey an Appendix "D" by J. A. Flemer describing this method. It was then being used in the Survey of Southeastern Alaska. Mention is made in that report of the possibility of attaching a Camera to a free or a captive balloon.

The airplane has greatly widened the field of application of Photographic Surveying. The European techical schools have taken the lead in this field both in their publications as well as in devising instruments for the practical application of this new method of Surveying. The European schools have a separate course for Topographic and Geodetic Engineering and another for Structural Engineering. We combine both in our Civil Engineering course. Due to the broadening of our Engineering curriculum by the introduction of cultural, business, economic and other allied subjects, specialized technical courses such as Photographic surveying were eliminated.

A course in Terrestrial Photographic Surveying has been given continuously at Syracuse University since the founding of the College of Applied Science. A generous contribution to our University last year from the Guggenheim Foundation for the Promotion of Aeronautics, made it possible to introduce new courses in Aerial Photo Surveying which are offered as optional courses in the last two years of the Civil Engineering curriculum.

Fig 1 shows an outline of the last two years of Course 1, Civil Engineering, and Course 1-A, Civil Engineering (Aerial Photographic Surveying Option). It will be noted that only the *advanced* courses in Minerology, Steel Design, Masonry Design, and Hydraulics are permitted to be omitted from the regular Civil Engineering program. A student is not required to take all the pre-

* Presented at the 38th Annual Meeting, S. P. E. E., Montreal, Canada, June 26–28, 1930.

scribed courses in Course 1-A, but may elect any course for which he has the necessary prerequisites. These new courses are open as electives for all Engineering students as well as for other students of the University who have the necessary preparation.

COURSE I

CIVIL ENGINEERING

Junior Year

Summer Surveying Camp (C_3 and C_4)

FIRST SEMESTER	Hrs.
Elements of Structural Engineering (S.D. 2)	3
Hydraulics (H. 1)	3
Hydraulic Laboratory (H. 21)	1
Materials Testing (M.L. 6)	1
Mechanics of Materials (S.D. 1)	5
Metallurgy (Chem.E. 6)	1
Mechanical Laboratory (M.L. 3)	1
Railroad Design (R. 23)	1
Steam Engines (H.P. 1)	3
Structural Design (S.D. 20)	1
Total	20

SECOND SEMESTER	Hrs.
Photo Surveying (A.P. 4)	3
Geology (Geol. 2b)	3
Cement and Concrete Testing (M.L. 7)	1
MINERALOGY (MIN. 9)	3
Railroad Bridge Design (S.D. 3)	5
Structural Design (S.D. 21)	2
Water Supply and Sewerage (H. 3)	3
Water Supply and Sewerage Design (H. 22)	1
Total	21

Senior Year

Summer Surveying Camp (C. 5) Elective

FIRST SEMESTER	Hrs.
BRIDGE AND BUILDING DESIGN (S.D. 22)	1
BRIDGES AND MILL BUILDINGS (S.D. 4)	3
Business English (Bus. Eng. 9)	2
Economics (Econ. 1)	3
ELECTIVE	3
Reinforced Concrete Bldg. Design (S.D. 23)	1
Principles Elec. Engineering (E.M. 5)	3
Reinforced Concrete (S.D. 5)	3
Selected Experiments in Elec. Engineering (E.L. 5)	1
Total	20

SECOND SEMESTER	Hrs.
Economics (Econ. 1)	3
ELECTIVE	3
Engineering Law (Bus.Law. 1)	2
HYDRAULIC MOTORS (H. 4)	3
Principles Elec. Engineering (E.M. 6)	3
MASONRY (S.D. 6)	3
MASONRY DESIGN (S.D. 24)	1
Selected Experiments in Elec. Engineering (E.L. 6)	1
HYDRAULIC LAB (H 22)	1
Total	20

COURSES IN CAPITAL LETTERS ARE OMITTED IN COURSE 1-A

COURSE 1-A

CIVIL ENGINEERING
(Aerial Photographic Surveying Option)

Junior Year

Summer Surveying Camp (C_3 and C_4)

FIRST SEMESTER	Hrs.
Elements of Structural Design (S.D. 2)	3
Mechanics of Materials (S.D. 1)	5
Metallurgy (Chem. E. 6)	1
Steam Engines (H.P. 1)	3
Railroad Design (R. 23)	1
Mechanical Laboratory (M.L. 3)	1
Structural Design (S.D. 20)	1
MAP PROJECTIONS (A.P. 1)	2
OPTICS (A.P. 2)	3
Total	20

SECOND SEMESTER	Hrs.
Geology (Geol. 2b)	3
Railroad Bridge Design (S.D. 3)	5
Cement and Concrete Testing (M.L. 7)	1
Structural Design (S.D. 21)	2
Materials Testing (M.L. 6)	1
Business English (Bus. Eng. 9)	2
GEODESY (A.P. 3)	3
Photo Surveying (A.P. 4)	3
Total	20

Senior Year

Summer Surveying Camp (C. 5) Elective

FIRST SEMESTER	Hrs.
Economics (Econ. 1)	3
Reinforced Concrete (S.D. 5)	3
Principles Elec. Engineering (E.M. 5)	3
Hydraulics (H. 1)	3
Reinforced Concrete Bldg. Design (S.D. 23)	1
Selected Experiments in Elec. Engineering (E.L. 5)	1
Hydraulics Laboratory (H. 20)	1
AERIAL PHOTO SURVEYING (A.P. 5)	3
AERIAL NAVIGATION (A.P. 7)	3
Total	21

SECOND SEMESTER	Hrs.
Elective (H. 4 and H 22 or S.D. 6 and S.D. 24)	4
Economics (Econ. 1)	3
Engineering Law (Bus. Law 1)	2
Principles Elec. Engineering (E.M. 6)	3
Water Supply and Sewerage (H. 3)	3
Selected Experiments in Elec. Engineering (E.L. 6)	1
Water Supply and Sewerage Design (H. 22)	1
AERIAL MAP CONSTRUCTION (A.P. 6)	3
ECONOMICS OF AERIAL MAPPING (A.P. 8)	1
Total	21

AERIAL PHOTOGRAPHIC SURVEYING COURSES NOT GIVEN IN REGULAR CIVIL ENGINEERING COURSE ARE SHOWN IN CAPITAL LETTERS

FIG. 1.

The course in Aerial Navigation had the largest registration. Many students elected it as a preparation for an Air Pilot's license. The students in Aerial Navigation received instruction in the use of navigating instruments and astronomical calculations for half of the semester in the Civil Engineering Department and the remainder of the semester was spent in the Electrical Engineering Department and in the University Meteorological Department where instruction was given in the use of the radio compass and radio beacons, and the interpretation of meteorological forecasts. This unusual method for dividing a student's time in a single course in three departments proved quite satisfactory.

Our Faculty Committee on the arrangement of these new courses as well as on the purchase of equipment was assisted by an Advisory Committee consisting of Captain Emory S. Land of the Guggenheim Foundation, J. B. Beadle of the Brock & Weymouth Co., Carl S. Bausch of the Bausch & Lomb Co., Col. Claude H. Birdseye of the Aerotopograph Corporation of America, and E. R. Polley of the Fairchild Aerial Surveys. The University is greatly indebted to this Committee for its valuable assistance.

It is necessary to outline the various types of Aerial Surveys which are now being executed, before attempting to suggest the necessary equipment required to teach these courses.

The Federal Bureau of Aeronautics lists 162 companies engaged in aerial mapping. On closer examination it is found that most of these are commercial aviation companies, who do occasional aerial photography incidental to their other activities. Such companies generally make either a single photograph of a small area, or a mosaic of a larger area, consisting of a series of photographs, reduced as nearly as possible to the same scale, and properly oriented. When sufficient ground measurements are available, and for areas of moderate relief, a mosaic may be made of fairly high degree of accuracy. Mosaics are very useful for planning engineering work and most of the aerial mapping done in the United States is of this type.

The Canadian Government has made extensive use of oblique aerial surveys in mapping their vast inaccessible areas of forest and lake country which is generally of very low relief. The distance of the horizon line from the centre of the plate permits the calculation of the tilt of the camera. The focal length of the lens and the height of the camera are the only addditional data necessary for compiling a plotting grid, by the principles of perspective geometry, by which line maps may be constructed from the oblique views. These Canadian aerial maps are published on a scale of 4 miles to the inch and resemble our Geological Survey maps except

that no contours are shown. The Canadian Government is also using aerial photography for reconnaissance for triangulation in their Geodetic Survey.

The equipment necessary for the construction of Mosaics as well as line maps by the Canadian method consist of an aerial camera, a rectifying camera, and apparatus for developing and printing photographs. Arrangements can be made with a commercial Aviation company for the necessary flying. It is even possible to obtain photographs from commercial photo aerial mapping companies for instruction purposes, and no special equipment would be required. A course in Terrestrial Photo Surveying should precede the instruction in aerial methods. A photo theodolite would be required for this work.

There will undoubtedly be an increasing demand for mosaic or pictorial maps made from aerial photographs. Their low cost as well as their richness in detail can not be duplicated by any other method of surveying. However the construction of mosaics involves more of photographic art than engineering.

The field of aerial mapping which is still in the process of development is its economic application to the construction of topographic maps. Considerable research is still required in this field.

The U. S. Geological Survey has used for some time aerial photographs to supplement their usual land methods. In recent years they have done considerable experimental work in aerial photography, and they are expecting to issue in the near future, topographic maps compiled from aerial photographs instead of plane-table sheets. The U. S. Coast and Geodetic Survey is also using aerial photo surveying methods in an increasing amount. It is expected that topographic mapping of large areas on scales comparable to those used by the U. S. Geological Survey and topographic maps of smaller areas on larger scales, in difficult and inaccessible territory, will be executed by aerial photo methods in less time, more accurately and cheaper than by the standard ground methods.

The following instruments were imported by our University from Germany and were used to instruct our students in the application of aerial photo surveying to topographic mapping.

Fig. 2 is a comparator by which the horizontal coördinates of points on a single photograph may be accurately measured. A Bulletin by Professor Church recently published by our University describes the analytical solution of the problem of topographic mapping from comparator measurements on aerial photographs. It is possible to calculate elevations of points appearing on two overlapping photographs.

Fig. 3 is a stereo-comparator. Two overlapping photographs which have been horizontalized by a rectifying camera, are viewed stereoscopically in this instrument. For points appearing on both photographs it is possible to measure the two horizontal coördinates

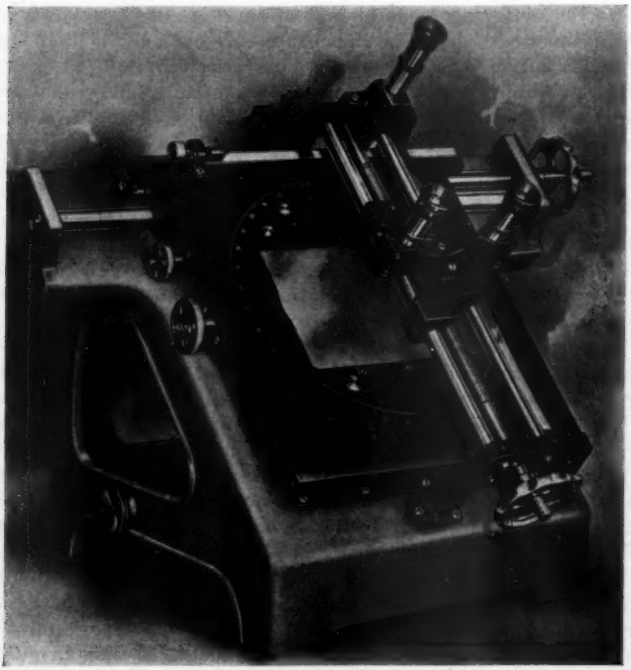


FIG. 2.

as well as the parallax, from which the vertical coördinate may be readily calculated. The principle of the stereo-comparator is used by the Brock & Weymouth Co. in their stereometer for drawing contours directly on the photographic plate.

Fig. 4 is a photogoniometer for measuring angular values on a single photograph with respect to the optical coördinates of the plate.

The aerocartograph is a German plotting machine for aerial topographic mapping, in which two photogoniometers are used in conjunction with a pantographic plotting device. There are sev-

eral other European plotting machines for aerial topographic mapping of which might be mentioned the Wild Autograph made in Switzerland, and the Zeiss Stereo Autograph, made in Germany. It was the opinion of our Advisory Committee that it would be preferable for instruction purposes to acquire the instruments previously listed rather than any of the automatic plotting ma-

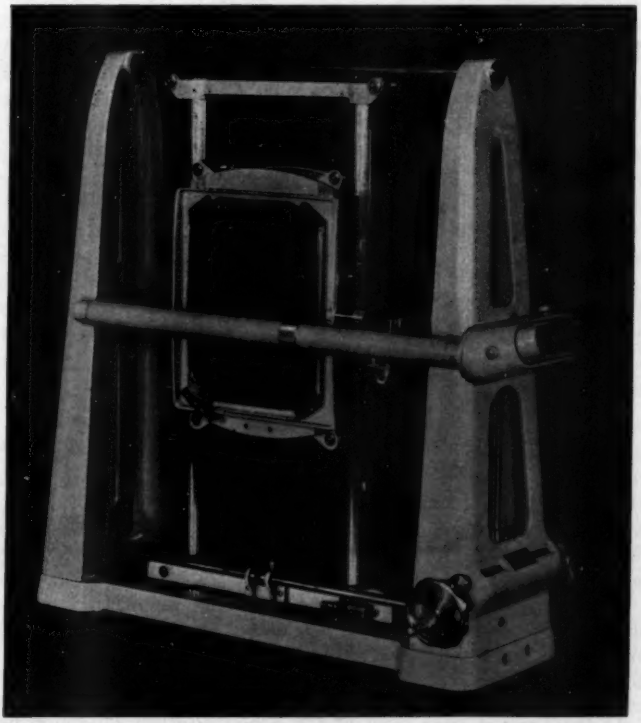
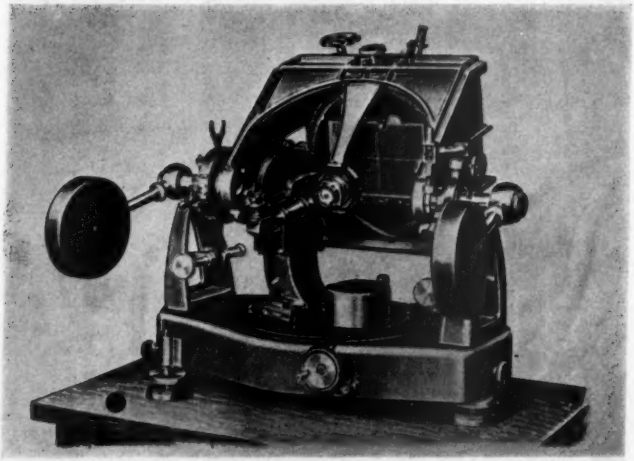


FIG. 3.

chines mentioned. There are several of these machines now being used in this country which can be inspected by our students after they have studied the principles upon which these machines depend. The present models are being constantly improved and it is difficult to predict as to what will be the ultimate solution of the application of aerial photo surveying to topographic mapping.

There are comparatively few schools which give comprehensive courses in aeronautical engineering, a specialized branch of Mechanical Engineering. It is therefore not expected that all technical schools will give a complete program of instruction in aerial photographic surveying. However engineering students should be familiarized with the various types of aerial maps and their economic application to various engineering projects.

PHOTO GONIOMETER
Bildmeßtheodolit
nach Prof. Dr.-Ing. Hugershoff
Patentiert in den meisten Kulturstaaten



Listen-Nr. 2111
Bildformat 13 × 18 cm, f = 18 cm
FIG .4.

At the present time most of the aerial photographic surveying and mapping is being done by the contract method, involving a lump sum bid for a certain project. There is an urgent need for standardized specifications for this work to insure fair and equitable bidding. It is hoped that a technical committee for this purpose will soon be organized. The Committee on Standardization of Technical Nomeclature of this Society could be of considerable assistance in assigning suitable names to the various types of so-called aerial maps now being produced.

REPORT OF THE MEETING OF THE INSTITUTIONAL DIVISION

As set up in the program of the Thirty-eighth Annual Meeting of the Society for the Promotion of Engineering Education, the Institutional Division held its session at 2:30 P.M., June 28, 1930, in Moyse Hall, Arts Building of McGill University. The Division program was modified somewhat by the addition of a report by H. H. Higbie on Engineering Research Subjects Suggested by Industries, and one by C. Francis Harding on Advantages and Disadvantages of Co-operative Research Projects With Industries, supplementing the report by R. A. Seaton on Engineering Research at the Colleges and Universities of North America. These three reports together constitute the report of the Society's Committee on Engineering Research for 1929–30. Dr. J. H. Parkins, of the National Research Council of Canada, presented the discussion of F. E. Lathe, the Director, and Dr. T. C. Fry substituted for John Mills of the Bell Telephone Laboratories.

Report of the Executive Committee

The Institutional Division for 1928–1929, Dean C. C. Williams, Chairman, made certain recommendations which were accepted by the Society Council at its meetings June 18 to 21, 1929. This action resulted in the creation of executive committee of the Division. The committee appointed consisted of, C. C. Williams, I. C. Crawford, Louis Mitchell, S. B. Earle, G. W. Case, H. M. MacKay and E. A. Hitchcock, Vice-President, for Chairman.

Another recommendation of the Division, and accepted by the Society Council, was the appointment of a committee of the Division "to study and report on the propriety of extending the institutional membership of the Society to non-collegiate institutions." This study was referred to the executive committee of the Division rather than to a separate committee. Due to pressure of required work, and interference over which he had no control, the chairman did not take up this matter with the executive committee. Therefore a new committee has a clear field and will not be hampered by any partial study by a previous group. Our recommendation, however, would be that this study be referred to a separate committee, which is the inference in the action taken by the Division June 20, 1929.

During the latter part of the year 1928–1929 your Executive Committee discussed, through correspondence, an educational question which was looked upon as of such importance as to merit further discussion, with a possibility of recommending its investigation to the Division. The committee, therefore, held a meeting at 10:00 A.M. June 28 at McGill University at which C. C. Williams, I. C. Crawford, H. M. MacKay and E. A. Hitchcock were present. This meeting resulted in this recommendation or suggestion to the Division, or its new Executive Committee, that the following topic or project be referred to a committee for investigation and study:

The subject proposed is "Coöperation between Industry and the Engineering Teacher." The particular phase of this subject to be investigated is, the employment of teachers by industry. The period of employment should be for one year, the teacher to have this opportunity every four or five years. The points raised in the discussion were as follows:

1. The desirability and value of such coöperation was beyond question.

2. The responsibility of industry to engineering education should be so recognized by it as to make such coöperation possible. While it is a fact that there are a few industries which are making possible such opportunities their number is small in comparison to the number of engineering teachers.

3. To make this coöperation possible, industry and college should combine on the matter of compensation. The great majority of engineering teachers could not afford to make financial sacrifices on account of family responsibilities.

4. While employment of teachers during the summer vacation is highly desirable, such individuals would be more valuable to industry if their period of service covered 12 or 15 months.

5. Certain teachers might be able to render a peculiar expert service to some industry, the value of which would be comparable to the teacher's salary and, therefore, no embarrassment would arise in this direction.

6. There was doubt expressed as to whether industry would be sufficiently philanthropic to pay teachers more than they would earn. Generally this should be so, due to recognition of responsibility. Better teachers produce better graduates for industry.

7. The chance of a teacher going to another institution after his period of experience and, therefore, that institution reaping the benefits derived by him and made possible by his university's cooperation. This point would be met if the system should be employed generally.

8. The possibility of the teacher obtaining credit in a graduate school on account of the character of the work carried on in industry.

9. The promotion and advancement in salaries of engineering teachers to be dependent, to a large degree, upon these contacts, and practical experiences, governed somewhat by the extent to which their value as teachers has been increased.

Respectfully submitted,

EXECUTIVE COMMITTEE OF THE
INSTITUTIONAL DIVISION

C. C. WILLIAMS,
I. C. CRAWFORD,
H. M. MACKAY,
E. A. HITCHCOCK, *Chairman*

REPORT OF COMMITTEE ON GRADUATING PERSONNEL

Your Committee on Graduating Personnel of the Institutional Division of the Society for the Promotion of Engineering Education begs to make the final report on its work. The committee made a preliminary report at the meeting in Columbus in 1929 and during the present year it has collected further data for its work.

The committee was appointed on December 28, 1928, and it was directed to study the subject: "Recognizing Native Executive Ability."

Our instructions contained the following:

The following procedure is suggested. It may be modified or amplified at the discretion of the committee.

1. What, if any, are the evidences of latent or embryonic executive or managerial aptitude manifest and recognizable in engineering students?

a. Correlation between scholastic achievements and success in executive or managerial positions in industry.

b. Ditto between scholastic achievement plus participation in student activities, (*a*) student organizations offices, (*b*) student enterprises, (*c*) athletics, (*d*) social and executive success in industry.

To be of most discriminative value, the success or failures should be of a certain number of cases (say 50) of men who had made good as executives and a similar number of those who had been definitely *given a chance* and failed. Studies made by United States Army would be pertinent.

2. If native executive aptitude could be identified with a reliability of say 75 per cent in senior students at time of graduation, to what extent would such knowledge be definitely usable by industries under present personnel methods? Under possible revision of personnel methods?

The committee has used data from three industrial companies and from classes of 1912 and 1916 of two engineering schools. As

stated in our last report, the returns from the industrial organizations record the achievement of men from different schools in industry, while the college replies give us the records of the graduates of definite institutions in different industries.

In the industrial group the study has included the examination of men who have achieved success as measured by the responsibility of their work and their positions in salary scales, and also the record of certain men who had entered with the same possibility of achievement but who have not been advanced in responsibility and salary.

In the school list, success has been measured by responsible positions and amount of salary, and the men have been divided into the same two groups.

It has not been possible to receive and publish the salaries received by the men in industry, although the men have been placed by those contributing the information into relative salary groups; and from the schools it has been thought unwise to give any relative figures regarding salary.

In making this study the committee has endeavored to collect the following data:

Class Standing:

Upper Tenth.
Upper Third (Outside Upper Tenth).
Middle Third.
Low Third.

Campus Activities in:

1. Athletics.
2. Social.
3. Literary.
4. Music.
5. Managerial.

The amount of achievement in these activities is graded as follows:

Substantial,
Some,
None.

Earnings during student days in amounts according to above table.

Summer work of student days in amounts according to the above table.

Position held at various times.
Salary at end of each two year interval.
Civic activities.
Size of family.
Systematic study since graduation.

The data under the last five heads have not been obtained in all cases.

The committee, in fixing success in executive work, has determined upon using the nature of the position held at present together with the relative salary within the organization as a measure of success. It has also endeavored to confine itself to those who have distinctly executive positions. It is found that much of the data received varies in such a way that merely the trends are disclosed, and it is interesting to note that these trends bear out the conclusions already arrived at by Colonel R. I. Rees in his excellent report made two years ago.

The present report is based on the records of 108 successful men and 41 unsuccessful men from industry, and 58 successful and 18 unsuccessful men from the classes of 1912 and 1913 from two engineering schools.

Scholastic Standing

In industry 27 per cent of the successful men stood in the upper tenth of the class, 40 per cent in the remaining part of the upper third, 26 per cent in the middle third, and 7 per cent in the low third. Of the unsuccessful men 5 per cent were from the upper tenth, 25 per cent in the remaining part of the upper third, 34 per cent in the middle third, and 27 per cent in the low third, and 9 per cent were not classified.

From the record of the engineering schools the following is found:

	Successful Men	Unsuccessful Men
Upper tenth	12%	6%
Remaining upper third	31	11

	Successful Men	Unsuccessful Men
Middle third	31%	28%
Low third	26	55

From the above it is seen that in industry over two-thirds of the successful men have been in the full upper third of their classes, and from the colleges a little under one-half of the successful men were in the full upper third.

The data from industry show that about one-third of the unsuccessful men had scholastic promise by their position within the upper third. Only 7 per cent of the successful men were in the lowest third, while 27 per cent of the unsuccessful men were drawn from this group. If the men with reported standing be considered, this percentage becomes 30 per cent.

Of those from the group of upper tenth men, the successful men number three times the unsuccessful men from the group.

Opinion of Faculty

The school records indicate that Faculty opinion has a predictive value for of the 58 successful men 73 per cent were judged to have executive ability, and of the 18 unsuccessful men 78 per cent were rated as having no executive ability.

College Earnings

The earnings during college days are of little value as means of predicting future success, as is seen from the table below:

	School Data		Industry Data	
	Successful Men	Unsuccessful Men	Successful Men	Unsuccessful Men
Substantial	23%	50%	25%	30%
Some	27	19	52	46
None	50	31	23	24

These data from the schools seem to indicate that fewer successful men have had earnings during their college course than the unsuccessful men, while in industry the percentage is about the same in the two classes with the unsuccessful men earning the greater amount.

Work During Summers

The record of work during the summer vacations (where reported) results in the following table:

	School Data		Industry Data	
	Successful Men	Unsuccessful Men	Successful Men	Unsuccessful Men
Substantial	38%	61%	38%	5%
Some	43	33	30	19
None	19	6	32	76

Of the successful men about 40 per cent have done substantial work during the summer in each group, while for those who have done some work and no work, the records from type schools and from industry differ. When the records of unsuccessful men are considered it is seen that the distribution from industry is opposite that from the schools.

Campus Activities

The school records do not give full data on the subject of campus activities. The data from industry result in the table below:

	Data from Industry	
	Successful Men	Unsuccessful Men
Substantial	30%	5%
Some	36	34
None	34	61

From this list there appears to be a trend indicating that campus activities are in some way indicative of future success, although it is rather the substantial achievement and the absences of any campus activity which are the predictive factors. The men who merely do some extra curricula work may be found later in either group while those who have had substantial campus achievement will probably be found among the successful men.

High Stand Men

An examination has been made of the records of men included in the upper thirds of their classes so as to see if there are any peculiar trends in this group. The following tables result:

Data from Men in the Upper Third Scholastic Group

CAMPUS ACTIVITIES—DATA FROM INDUSTRY

	Successful Men	Unsuccessful Men
Substantial	28%	3%
Some	36	34
None	36	58

Summer Work

	College Data		Industry Data	
	Successful Men	Unsuccessful Men	Successful Men	Unsuccessful Men
Substantial	21%	66%	51%	0%
Some	50	34	21	50
None	29	0	28	30

Earnings

	College Data		Industry Data	
	Successful Men	Unsuccessful Men	Successful Men	Unsuccessful Men
Substantial	19%	66%	31%	23%
Some	24	0	46	54
None	57	34	27	23

The data of campus activities of the high stand men are practically of the same relative percentage in the degrees of achievement as is shown by the data of all men. This indicates that relative participation is practically the same throughout the various scholastic groups and that one would expect greater success from those who have had substantial achievement.

On examining the summer work data it is found that the successful men from the upper third, as reported by the schools, have not worked as much as the average of all successful men reported by them, although from industry the conclusion is the opposite. There is little difference, however, between the records.

Among the unsuccessful men in each of the two tables of unsuccessful men there is a complete divergence of distribution in those from industry and from the schools. The distribution between those complete lists of men and those for the upper third of the schools and in industry are somewhat the same.

In considering the data regarding earnings during college days it is seen that from the schools the reports show that most of the successful men from the complete list and from the upper third have earned none of their expenses, while the data from industry show that the largest number have earned some of their expenses. This latter finding is the same for the unsuccessful men in industry although school data in both tables show that the greatest number have earned a substantial amount of their expenses.

The industrial reports show that success or failure can not be judged by the earnings of the college student. The reports from the schools indicate that substantial student earning achievement is not indicative of later success.

Post Graduate Activities

The reported data regarding later activities of these men, although incomplete, are collected in the table below:

POST GRADUATE ACTIVITIES OF SUCCESSFUL MEN

Further Study

	Industry	School
Systematic	26%	58%
General	52	10
None	22	32

Civic Activity

	Industry	School
Substantial	19%	22%
Some	29	22
None	52	56

These tables show distinctly that the successful men study after graduation. Over two-thirds of those reporting are carrying on some study and many of these are doing systematic work.

A little less than one-half of these men find time to do community work.

Conclusions

The data studied have shown no marked kind of achievement by a student by which future executive success can be predicted. There are some indicators which may be of value. They are as follows:

1st. Scholastic Standing:

In general, high standing indicates future success in the ratio of about three out of four cases, and low standing means failure in about three out of four cases.

2d. Opinion of Faculty:

The opinion of the faculty regarding success or failure was shown correct in three out of four cases.

Campus Activities, College Earnings and Summer Work do not seem to furnish information regarding future success.

The records in these different achievements of the men in the complete upper third seem to distribute among the different classes of activities in about the same way as is shown by the records of all men of the two general classes. This indicates that the distribution is the natural one among the records used and is not peculiar to the man of particular mental attainment.

The records show that most successful men continue to study after graduation and about one-half of them are interested in community affairs.

The committee was asked to state if native executive aptitude could be identified with a reliability of say 75 per cent in senior students at time of graduation, to what extent would such knowledge be definitely usable under the present personnel methods or a possible revision of personnel methods.

It is the opinion of the committee that scholastic standing is the factor which has almost this degree of reliability and that present or future personnel methods have been based on this. The facts that men of high standing have failed to make good in after life and that the low stand man may and does at times develop later into a successful man, furnish the justification for including him in the list of selected seniors if the personal impression made by such a man is satisfactory to the personnel officer. The 25 per cent

element of doubt would still make it necessary for the personnel officer to give the man of attractive personality in the lower scholastic rank a chance to make good.

The committee believes that one element or even two or three elements are not sufficient on which to base a definite selection.

Respectfully submitted,

ARTHUR M. GREENE, JR., *Chairman*

REPORT OF COMMITTEE ON ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

BY R. A. SEATON, *Chairman*

Supplement to February, 1931,
JOURNAL OF ENGINEERING EDUCATION

CO-OPERATIVE ENGINEERING EDUCATION IN THE SOUTHEAST

Although the severe economic depression has made its inroads on all kinds of business the co-operative students at Georgia Tech and at other institutions in this section are surviving with even greater possibilities. Such engineering concerns as the Southeastern Power, the railroad shops, the steel companies, the Southern Bell, the Westinghouse, the General Electric, and many other corporations of like nature are maintaining pretty nearly their full quotas; this indication discloses the real value of the Co-operative Plan to the engineering field.

At present when employment is scarce; when the manager of employment tells the college coordinator or the solicitor for student labor that only men of families striving for mere existence will be used on work, the real problem of modern technology is at hand. Social questions and problems are at battle against the economic and mechanical forces of industries and nature. Will the modern entrepreneur show himself a benefactor to the unemployed who may be totally unfitted for the technical work or will he resort merely to production for profits? Perhaps for a definite, short time a restricted class of people without work will be used regardless of their skill or ability, but after all in this machine age, time of mass production, period of high-pressure selling and ruthless competition, this decade of colossal mergers, the business manager will find need and urgent need for the alert co-operative students who can quickly adjust themselves to the exigencies of the moment, to the latest mechanical contrivances which are necessary for the tense competition in this civilization. Only a few who are trained in modern technology can be used profitably in the industries of today. Thus the reaction to continue the services of co-operative employes notwithstanding the depression is already noticeable among the captains of industries in this Southeastern section.

The co-operative student who has integrity, fortitude, ingenuity, and pride in achievement as well as technical ability is in great demand especially during these hours of unremitting sources of strain and worry. In earlier days the rigors of the climate, the maladies of contagious disease, the savage and pirate marauders were dreaded and feared, but today we live in apprehension of local, national and international riots brought about through economic maladjustment. No longer does one view the economic distress as

a personal problem; he contents himself by attributing the trouble to some general cause as the tariff, overproduction, the Patrician money lords, etc. People now seem to have lost all orientation of themselves. The student who has studied political economy, literature, and history along with the technical engineering subjects is a great help both in a technical and cultural way to the industry especially now when every business concern or manufacturing plant has so much discontent and unhappiness among its laboring classes and even among its office forces. College students are refreshing and philosophically helpful to the masses of employes or wouldbe employes who are becoming distrustful and alarmingly pessimistic toward our highly developed civilized world.

Although the co-operative student may think that he is having the most difficult year of all years to survive, he is perhaps learning more now than ever before from the outside contact with his practice work. A practical application in sociology, or economics, or ethics, or psychology, or in any of the humanities can be experienced in almost any industrial plant of today. The industrialist also now more than ever before realizes the importance of giving employment to co-operative students, who will not be such easy victims to the ravages of nervous and mental disease caused by the strain of sociological unrest and who will not wonder because the individuality which formerly meant so much to a successful organization is now submerged with the predominance of mass production. Thus the co-operative students, because of their particular educational training, are in demand in the Southeast, and should be in demand throughout the industrial world.

J. E. McDaniel.

THE T-SQUARE PAGE

FREDERIC G. HIGBEE, *Editor*

SECTIONAL VIEWS: THE ENGINEERING DRAWING SUMMER SCHOOL

". . . The whole status of engineering drawing would be raised materially if the instructors in the other courses in the curriculum would realize that they would be even more highly credited for the teaching they were doing in applied science and engineering work, if they too would insist on neat representation whenever the graphical language is used, just as the employer insists and financially encourages neatness and accuracy of expression on the part of the engineering graduate whom he employs."

DEAN F. DER. FURMAN.

"Drawing is not a side line to be carried by an instructor of physics or chemistry. To delegate its direction to the inexperienced or immature is a crime against the student and a detriment to the engineering profession. It should be taught by a specialist trained in knowledge and skill, with a background of drawing board experience and a teaching instinct, who appreciates both the importance and the difficulty of his work and accepts with an earnest enthusiasm the responsibility of training the young minds intrusted to him in a subject of such indispensable value that without it modern engineering could not exist."

PROF. THOMAS E. FRENCH.

". . . The development of intelligence in the student is far more subtle and excites little or no interest in him. It is characteristic of student psychology that he is very keen for information and for experience that promises to be useful to him after graduation, but he is very indifferent to the cultural value of any study, especially if he is convinced that it is non-essential. He believes in education *theoretically*, but he prefers to be stuffed with information."

PROF. WM. GRISWOLD SMITH.

"An atmosphere should be created in the drawing department that will encourage every member of the staff to attach himself to a national organization or association with others that will permit him to present his opinions and suggestions in such a way that they will receive the widest attention and have the greatest influence on those whom it is desirable he should know and be known by. The organization under whose auspices we are now assembled has done much in the past and will do more in the future to raise the status of the engineering teacher and to make his voice effective in the councils of educational leaders. The drawing teacher must not lag in doing his part."

PROF. H. H. JORDAN.

COLLEGE NOTES

Massachusetts Institute of Technology.—Construction has been started on a new building which will house the research sections of Physics and Chemistry. The structure will be 300 ft. by 60 ft. and will consist of four floors and a basement.

As spectroscopy is becoming more and more important in the field of atomic structure a special vibrationless, constant-temperature laboratory will be built for housing the spectroscopic equipment. The two floors of this building will be specially supported separate from walls and roof, and the whole building will be so well insulated that if the outside temperature were suddenly to change one hundred degrees it would take the interior about a month to change one degree.

It is also planned to construct a cryrogenic laboratory for research at extremely low temperatures. This laboratory will contain plants for the manufacture of liquid nitrogen, hydrogen and helium in quantity.

The first play presented this year by the Tech Dramashop was Gogol's "Marriage." This is a Russian play which depicts the customs and foibles of the Russian bourgeois class about the middle of last century. Although this type of play was unfamiliar to most of the audience it met with an enthusiastic reception.

BOOK REVIEW

Electric Circuit Analysis. By MICHEL G. MALTI, of Cornell University. Published by John Wiley & Sons. Price $4.50.

This book contains nineteen chapters, treating the subject of alternating current circuit analysis from a mathematical viewpoint. There are 389 pages. The appendix includes theorems and their proofs together with mathematical and physical tables.

At the end of each chapter many problems are recorded, which in the writer's opinion tends to make such a book as this more *"usable"* for the large majority of students who get principles best by means of some drill.

The author has undertaken to give some physical concepts preceding his purely mathematical treatments, but the problems seem to emphasize the importance of knowing mathematics.

The book should find its largest application with students who are majoring in Electrical Engineering. Teachers who prefer

mathematical treatments of the simplest fundamentals will probably adopt this book for their alternating current circuit courses. After the first three chapters have been *mastered,* the remaining sixteen chapters can be taken up in almost any order one might wish to consider them.

R. C. G.

EMPLOYMENT SERVICE

To the Members of the Society:

In order that the Society may be of further assistance to you, we are compiling a list of vacancies which will be open in the engineering schools of the United States and Canada next year.

If you desire to make a change in your position, please advise us the type of position you wish; the section of the country in which you prefer to live; the salary expected. We should also have full information concerning your qualifications so that we may refer these to the institution seeking a man of your ability.

All information received in response to this notice will be kept confidential and sent only to institutions where there is an opening which will benefit you.

This information should be in our hands at once as appointments for next year will be made within the next two months.

If you have vacancies in your department, please list them with us.

There is no fee attached to the above service.

Very truly yours,

F. L. Bishop,
Secretary.

SECTIONS AND BRANCHES

The **South Dakota Section** held the fourth annual meeting at the Hotel Lincoln, Watertown, S. D., January 8, 1931. Nineteen members and visitors were in attendance.

The morning session began with a short business meeting, after which the president of the Section, Dean L. E. Akeley of the University of South Dakota, gave his presidential address, "Some Liberalizing Objectives in Engineering Education." This address was followed by two papers, "Inspection Trips for Engineering Students," by Prof. H. S. Carter of South Dakota State College and Prof. H. E. Brookman of the University of South Dakota. All three papers were quite widely discussed.

"The Teaching of High School Mathematics," by Dean H. M. Crothers, South Dakota State College, was the first paper presented at the afternoon session. This paper created considerable interest and was well discussed by the members of the Section and visitors from the local and neighboring town high school faculties.

The last paper on the program was presented by Mr. H. B. Porter, Plant Extension Engineer, Northwestern Bell Telephone Co., Omaha, Nebraska. The paper was entitled "The Application of Engineering to Present Day Problems." This paper was filled with optimistic, common sense philosophy applicable to engineering student, engineering teacher and engineering graduate.

In a short business session the following officers were elected for the coming year:

Prof. H. S. Carter, President, South Dakota State College.
Prof. E. E. Clark, Vice-President, South Dakota School of Mines.
Prof. H. E. Brookman, Secretary-Treasurer, University of South Dakota.

E. E. CLARK,
Secretary-Treasurer.

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ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

Prepared for the Committee on Engineering Research, S.P.E.E., and presented at the 38th annual meeting of the Society at Montreal, Canada, June 28, 1930,

By R. A. SEATON, Kansas State Agricultural College, *Chairman*

The Committee on Engineering Research of the Society for the Promotion of Engineering Education undertook three projects for the year 1929–30 as follows:

1. The collection and preparation for publication of data on engineering research in the colleges and universities of North America, delegated to the writer who is Chairman of the Committee;

2. The collection and preparation for publication of a list of subjects for engineering research suggested by the research departments of industrial organizations as being properly suited to university facilities and personnel and not likely soon to be undertaken by men employed in industry, delegated to Professor H. H. Higbie, University of Michigan, a member of the Committee; and

3. The preparation of a discussion outlining the advantages and disadvantages of cooperative research projects with industry, reviewing some of the experiences of educational institutions with such projects, and touching on problems of administration as well as of technical research, assigned to Professor C. F. Harding, Purdue University, a member of the Committee.

The other members of the Committee, Mr. H. S. Sheppard, American Telephone and Telegraph Co., and Dean G. M. Braune, University of North Carolina, have rendered valuable assistance in planning the work of these projects.

This portion of the report of the Committee deals with the first of the three projects. Separate supplementary reports will be made by Professors Higbie and Harding on the second and third projects.

The project of collecting and preparing for publication data on engineering research in the colleges and universities of North America was undertaken in the belief that information of this character would be informative and stimulating to those within the colleges and universities who are or should be doing engineering research work, and that it might help to secure appreciation and support from those outside the educational institutions who are interested in engineering research.

Since the Engineering Experiment Station Record Summary, 1929, published last year by the Engineering Experiment Station Committee of the Association of Land-Grant Colleges and Universities, under the editorship of the writer, contained, for those institutions, essentially the information desired by our committee, it was decided not to include those institutions in our study. The data in that Summary are fairly complete and recent, and the booklet can be obtained easily and inexpensively. To have included the land-grant institutions would have increased considerably the work of preparing the report and the expense of publishing it, without corresponding benefits.

Requests for information on engineering research were sent to all institutions included in the list published on pages 953 to 956 of the JOURNAL OF ENGINEERING EDUCATION, except the land-grant institutions, and also to the institutional members of the S. P. E. E. in Canada and Mexico as published on pages 8 to 13 of the supplement to the January, 1930, JOURNAL.

A splendid response was obtained to the questionnaire. Of 110 institutions addressed all but 13 replied, and most of those replying furnished part or all of the information requested. Many very carefully prepared reports were received and the writer wishes to express his sincere appreciation for the excellent cooperation he was given. Only those institutions from which some reply was received have been listed in the report.

The report includes information, so far as it was reported by the various institutions, on their engineering research, as to administration; organization; funds available; number of employees; channels of publication; lists of bulletins and circulars published, with title, author, year of issue, and price of each; lists of live projects, with titles and names of persons in charge; and lists of discontinued or completed projects which resulted in valuable data not published in bulletins or circulars but available; all arranged by states in alphabetical order.

In the Statistical Summary, a "—" opposite the name of any institution in any particular column does not necessarily mean "none," but does mean either "none" or "information on this point not reported." Data from the Summary of Engineering Research at the Land-Grant Colleges and Universities, referred to above, have been included in this summary in order to make the statistical picture as nearly complete as possible.

A study of the data included in the report impresses one with the very indefinite meaning attached to the term "engineering research." This is, of course, to be expected since both of the terms "engineering" and "research" are commonly very loosely used and both terms are difficult to define so that the definitions

shall include everything desired and no more. Work done by engineering experiment stations, other research organizations, or individuals, under the name of engineering research partakes at times of the nature of routine or commercial testing, engineering services, development work, industrial investigations, geological investigations, or pure science investigations (especially in chemistry, physics and geology). It is convenient to group various projects of such character, not strictly engineering research in the narrow sense, under the general classification of engineering research, and to administer it under the engineering research organization, and probably there is no valid objection to doing so. It should be noted in this connection that some of the funds reported are devoted to the support of work of this character, and some of the employees reported are engaged in such work.

It is apparent that the character of the organization of engineering research in the different institutions varies widely, with all gradations from a strictly individual matter left wholly to the initiative and responsibility of teachers who carry full time teaching loads and crowd the research work into odd moments, and who find a few dollars available here or there to finance the necessary expenditures, to a well organized procedure, with definitely assigned responsibilities, financial support, and time allotments. The tendency seems to be toward more definite organization, but in most institutions it appears that the work is, at present, but loosely organized. In a number of the institutions it seems to be difficult to tell whether the work classed as engineering research and industrial contacts is being done by the institution, or by the individual.

Mining research seems to be better organized and better financed, generally, than other lines of engineering research. Nine of the twenty-two engineering research organizations reported in the non-land-grant institutions of the United States seem to be engaged chiefly or wholly in mining, metallurgical, and geological investigations.

It seems to the writer that it would be highly beneficial to engineering research if the work were more definitely organized in many of our institutions, not for the purpose of prescribing limitations, but to provide a definite recognition for the work in the programs of the institutions and to provide organized effort for the solution of the common problems of those faculty members engaged in such work.

But few full time employees were reported except in Mellon Institute of the University of Pittsburgh and the Department of Engineering Research of the University of Michigan, though in a considerable number of institutions fairly definite time allotments for engineering research seem to be provided for those devoting part time to this work.

The general tendency seems to be for the institutions with the more highly organized research work to issue bulletins, circulars, or reprints numbered consecutively in one or more series. These constitute a more or less systematic record of the more important investigations of the institution. However a number of institutions doing considerable engineering research work do not issue bulletins or circulars, but depend upon publication of reports of the work in journals of the professional societies and in the technical press.

Two comments in the replies to requests for information impressed the writer as being especially significant. Director Palmer C. Ricketts of Rensselaer, referring to the engineering research work in his own institution, wrote "Some of it is valuable, and some valuable only on account of its influence on the students who are making the investigations." Dean Whitehead of Johns Hopkins wrote that research is regarded as "A normal function of all faculties in Johns Hopkins University." The writer believes it would be highly desirable for all institutions engaged in engineering education to regard engineering research as a normal function of their faculties, valuable both for the results obtained in extending the boundaries of knowledge of fundamental principles and their applications, and for the effects of such research work in developing students and faculty members.

ENGINEERING RESEARCH AT THE NON-LAND-GRANT COLLEGES AND UNIVERSITIES OF NORTH AMERICA *

ADMINISTRATION, ORGANIZATION, FUNDS, EMPLOYEES, CHANNELS OF PUBLICATION, BULLETINS AND CIRCULARS PUBLISHED, LIVE RESEARCH PROJECTS, AND DISCONTINUED OR COMPLETED PROJECTS WHICH RESULTED IN VALUABLE DATA NOT PUBLISHED IN BULLETINS OR CIRCULARS BUT AVAILABLE, ARRANGED BY STATES IN ALPHABETICAL ORDER.

IN THE UNITED STATES

ALABAMA

UNIVERSITY OF ALABAMA, University. George H. Denny, President; Geo. Jacob Davis, Jr., Dean of the College of Engineering.

Engineering Research Organization: Engineering Experiment Station, created by the legislature and Board of Trustees, 1907.

Channels Publication: Bulletins of the University and Bulletins of the U. S. Bureau of Mines.

Persons to Whom Requests for Research Information Should Be Addressed: Dean, College of Engineering, for University bulletins and research. Director, Bureau of Mines, for Bureau of Mines bulletins and research.

Engineering Experiment Station Bulletins Published

Bulletin No. 1. Coal Losses in Alabama, by Cash.

Bulletin No. 2. Specific Gravity Studies of Alabama Coal, by Gandrud and Britton

U. S. Bureau of Mines Papers

resulting from studies and experiments
conducted at the University of Alabama Station.

Bulletin No. 239. Iron Ore (Hematite) Mining Practice in the Birmingham District, Alabama, by W. R. Crane.

Bulletin No. 278. Magnetic Concentration of Iron Ores of Alabama, by Oscar Lee and others.

* For similar information for the Land-Grant Colleges and Universities of the United States for 1928–1929 see *Engineering Experiment Station Record Summary, 1929*, edited by R. A. Seaton and published by the Engineering Experiment Station Committee of the Association of Land-Grant Colleges and Universities. Copies can be secured for fifty cents each from Dean Paul Cloke, University of Maine, Orono, Maine.

Bulletin No. 312. Bauxite: Float-and-Sink Fractionations and Flotation Experiments, by B. W. Gandrud and others.

Technical Paper No. 296. Size and Character of Grains of Non-Metallic Minerals Fillers, by W. M. Weigel.

Technical Paper No. 343. Georgia and Alabama Clays as Fillers, by W. M. Weigel.

Technical Paper No. 377. Red Iron Ores and Ferruginous Sandstones of the Clinton Formation in the Birmingham District, Alabama, by W. R. Crane.

Technical Paper No. 379. Strength of Ore and Top Rock in the Red Iron Ore Mines of the Birmingham District, Alabama, by W. R. Crane.

Technical Paper No. 397. Composition of Materials from Various Elevations in an Iron Blast Furnace, by S. P. Kinney.

Technical Paper No. 407. Development, Mining, and Handling of Ore in Folded and Faulted Areas, Red Iron Ore Mines, Birmingham District, Alabama, by W. R. Crane.

Serial No. 2761. Magnetic Concentration of Flue Dust of the Birmingham District, by Oscar Lee and others.

Serial No. 2779. Stream Measurement in Relation to Mine Drainage, by W. R. Crane.

Serial No. 2860. Flotation of Low-Grade Phosphate Ores, by H. M. Lawrence.

Serial No. 2925. Losses of Phosphate in the Land Pebble District of Florida, by H. M. Lawrence.

Serial No. 2937. Gravity Concentration of Alabama Oolitic Iron Ores, by B. W. Gandrud and others.

Papers in Process of Publication

1. Increased Recoveries of Phosphate in the Land Pebble District of Florida, by H. M. Lawrence.
2. Gravity Concentration Tests on Certain Florida Phosphate Sands, by H. M. Lawrence.
3. Washability Studies of the Mary Lee Seam at Lewisburg No. 2 Mine, by B. M. Bird and others.
4. Washability Studies of the Clark Seam at Mafvel Mines Nos. 1 and 3, by B. M. Bird and others.

CALIFORNIA

CALIFORNIA INSTITUTE OF TECHNOLOGY, Pasadena. Robert A. Millikan, Chairman of the Executive Council and of the Division of Physics, Mathematics, and Electrical Engineering; A. A. Noyes, Chairman of the Division of Chemistry and Chemical Engineering; Franklin Thomas, Chairman of the Division of Civil and Mechanical Engineering; C. C. Thomas, Chairman Committee on Engineering Research.

Engineering Research Organization: Committee on Engineering Research.

Channels of Publication: Technical journals. Other results on file in student theses, dissertations for Doctors' degrees, and reports by members of the staff. No engineering research bulletins have been issued.

Live Research Projects

Department of Civil Engineering

Various phases of the two following problems have been completed and reported upon, and further work is in progress on each of them:

1. Stresses in Framed Structures Caused by Earthquakes. R. R. Martel.
2. Siphon Spillways. Franklin Thomas.

Department of Electrical Engineering

1. Character of the Electric Arc in a High Vacuum. Lash and Haeff.
2. Character of the Electric Arc in Gas at Low Pressure. Lee, Holdaway, and Fracker.
3. Surface Flashover Characteristics of Solid Insulators—Faradoid Effect. Maxstadt.
4. Influence of Surroundings and History on Surface Resistance of Insulators. Kinney.
5. Experiments with High Voltage Vacuum Switches. Sorenson and Pleasants.
6. Design Equations for Induction Motors. Hoover.
7. Dielectric Losses—Influence of Temperature. Ager.
8. Optical Oscillograph Design for Recording Lightning Strokes. Wolfe.
9. Insulation Behavior When Subject to Electric Surges. Williamson.
10. Stationary Commutator Rectifiers. Stipp and Strong.
11. Photometric Tests of Neon Lamps. Boren and Atwater.
12. Cathode Drop in Neon Tubes. Lee, Holdaway, and Fracker.
13. Design for D. C. Amplifier. Sheffet and Reed.
14. Sensitivity of Photoelectric Cells Throughout Visible Spectra. Russell and Ross.
15. Thermionic Currents at High Field Strength. Mackeown.

Department of Mechanical Engineering

1. Development of a Method for the Determination of Viscosities of Mechanical Mixtures such as Slurries. Determination of the actual viscosities of such mixtures and the variation with the percentage of water, fineness of particles, etc.
2. Investigation of Means of Increasing Output of Liquid-Air Machine.
3. Investigation of Strength and Hardness Relationships of Certain Solid Solution Proportions of the Noble Metals.
4. Determination of the Difference in the Constitution of Sorbite and Trustite.
5. Determination of the Quality of Wet Steam by Means of the Electric Steam Calorimeter, Invented by C. C. Thomas. In cooperation with power companies interested in high pressure steam plants.

Department of Mechanics

1. Investigation of the Strength in Shear of Wooden Beams With and Without Overhang. Completed and sent in for publication.
2. Effect of Energy as Delivered by Small Masses with High Velocities and Large Masses with Low Velocities in Deforming Specimens. Deformation Varying from Zero to Rupture.
3. Investigation to Detemine Whether Shore Scleroscope Would Show. Different Rebounds for Specimens under Stress and Specimens not under Stress.
4. Investigation of the Variation of Modulus of Elasticity under Impact.
5. An Investigation of the Effect of Powdered Tuff in Concrete Exposed to Sulphate Water. Complete but not published.

Discontinued or Completed Projects

Department of Mechanical Engineering

1. Development of a Method for the Quick and Accurate Determination of the Fineness Distribution in Cement. Thesis of Dr. R. T. Knapp.
2. Investigation of the Characteristics of Centrifugal Pumps as a Function of the Viscosity and Vapor Pressure of the Liquid. Published by Goulds Pumps, Inc., Seneca Fall, N. Y., Bulletins 126 and 130, by R. L. Daugherty.

UNIVERSITY OF SANTA CLARA, Santa Clara. Cornelius Joseph McCoy, President; George Leonard Sullivan, Dean of the College of Engineering.

No engineering research organization.

No engineering research reported.

UNIVERSITY OF SOUTHERN CALIFORNIA, Los Angeles. R. B. von KleinSmid, President; Philip S. Biegler, Professor of Electrical Engineering and Dean of the College of Engineering.

No engineering research organization.

Employees for 1929–30: Part time, 5, estimated equivalent to 1 full time.

Channels of Publication: Engineering societies proceedings. No engineering research bulletins have been issued.

Persons to Whom Requests for Research Information Should Be Addressed: Division of Chemical Engineering, Dr. W. W. Scott; Division of Petroleum Engineering, Professor John F. Dodge; Division of Electrical Engineering, Professor Philip S. Biegler.

Live Research Projects

1. Vanadium Catalyst for the Oxydation of Sulphur Dioxide. W. W. Scott.
2. The Effect of Radio Activity on Oils. L. D. Roberts.
3. The Variation in Grain Size of the Oil Sands in the Santa Fe Springs Oil Field, with Particular Reference to the Design of Screen Pipe. J. D. Robertson.
4. Study of Load Losses in Large Synchronous Machines.
5. Power Limits of Electrical Transmission Systems. In cooperation with the Bureau of Power and Light of the City of Los Angeles.

Completed Project

1. Study of the Movement of Transmission Conductors Resulting from Short-Circuit Forces. Thesis for M.S. in E.E. degree, now on file in the University Library.

STANFORD UNIVERSITY, Stanford University. Ray Lyman Wilbur, President; Robert Eccles Swain, Acting President; Theodore J. Hoover, Dean of the School of Engineering.

No engineering research organization reported.

Funds Available for 1929–30: No stipulated sum, but variable amounts from current funds.

Channels of Publication: Proceedings of national and state engineering societies and the technical press.

No research projects reported.

COLORADO

UNIVERSITY OF COLORADO, Boulder. George Norlin, President; Herbert S. Evans, Dean of the College of Engineering.

No engineering research organization. Some engineering research is conducted by individual faculty members.

Channel of Publication: The technical press.

No engineering research bulletins or live projects reported.

COLORADO SCHOOL OF MINES, Golden. Melville Fuller Coolbaugh, President.

Engineering Research Organization: Metallurgical and Mining Research Experiment Station.

Funds Available for 1929–1930: Approximately $40,000 for the Station.

Channel of Publication: The Colorado School of Mines Quarterly.

No live projects reported.

The Colorado School of Mines Quarterly—Contents

Vol. I, No. 1. July, 1906. Commencement address: How to Succeed, by Judge J. H. Richards.

Cooperation between the State Mining Bureau and the State School of Mines, by V. C. Alderson.

Vol. I, No. 2. October, 1906. Catalog edition, 1906–1908.

Vol. I, No. 3. January, 1907. Dedication of Simon Guggenheim Hall.

Vol. I, No. 4. April, 1907. Book of Views.

Vol. II, No. 1. July, 1907. Commencement Address: The Engineer and the Age, by Frank E. Shepard.

Early History of the Colorado School of Mines, by Captain James T. Smith.

Vol. II, No. 2. October, 1907. Some Minerals Recently Received by the Colorado School of Mines, by Horace B. Patton.

Geological Field Work at the Colorado School of Mines, by Charles E. Smith.

Vol. II, No. 3. January, 1908. Book of Views.

Vol. II, No. 4. April, 1908. Mining Engineering in the United States, by Victor C. Alderson.

Vol. III, No. 1. July, 1908. Commencement address: The Worth of an Engineer, by Thomas F. Walsh.

Vol. III, No. 2. Oct., 1908. Catalog edition, 1908–1910.

Vol. III, No. 3. Jan., 1909. Rare Metals: Uranium and Vanadium, by H. Fleck.

Vol. III, No. 4. April, 1909. Tungsten in Colorado, by H. R. Van Wagenen.

Vol. IV, No. 1. July, 1909. Commencement address, South Dakota School of Mines: Artist or Artisan—Which? by V. C. Alderson.

Vol. IV, No. 2. Aug., 1909. Commencement address: The Mining Profession, by John Hays Hammond.

Vol. IV, No. 3. Oct., 1909. Preliminary Report of the Radioactivity of the Carnotite of Southwest Colorado, by Herman Fleck and W. G. Haldane.

Vol. IV, No. 4. Jan., 1910. Book of Views.

Vol. V, No. 1. April, 1910. Radium and Radioactivity, by L. F. Miller.

Vol. V, No. 2. July, 1910. Commencement address: The Engineer of the Future, by A. A. Blow.

Vol. V, No. 3. Oct., 1910. Scope and Progress of the Mining Industry in Colorado, by the faculty of the Colorado School of Mines.

Vol. V, No. 4. Jan., 1911. Catalog edition.

Vol. VI, No. 1. April, 1911. An Extension of the Dewey System of Classification as Applied to Metallurgy and Metallography and Assaying, by R. M. Keeney.

Vol. VI, No. 2. July, 1911. Commencement address: Constitutional Basis of Citizenship in the United States, by William F. Slocum.

Vol. VI, No. 3. Oct., 1911. Scope and Progress of the Mining Industry in Colorado, by the faculty of the Colorado School of Mines.

Vol. VI, No. 4. Jan., 1912. Proceedings of the Colorado Mining and Metallurgical Association, Denver, December 28, 1911.

Vol. VII, No. 1. April, 1912. Book of Views.

Vol. VII, No. 2. July, 1912. The Experimental Ore Dressing and Metallurgical Plant of the Colorado School of Mines, by Victor C. Alderson.

Vol. VII, No. 3. Oct., 1912. An Extension of the Dewey System of Classification as Applied to Mining, by Carl A. Allen.

Vol. VII, No. 4. Jan., 1913. Catalog edition, 1912–1914.

Vol. VIII, No. 1. April, 1913. Some Recent Developments at Leadville, by G. Montague Butler.

Vol. VIII, No. 2. July, 1913. Commencement address: Principles More Important than Practice in Technical Education, by Dr. James Douglas.

Vol. VIII, No. 3. Oct., 1913. Physiography of Golden and Vicinity, and Its Relation to the Geologic Structure, by Hyrum Schneider.

Vol. VIII, No. 4. Jan., 1914. Book of Views.

Vol. IX, No. 1. April, 1914. Catalog edition, 1914–1916.

Vol. IX, No. 2. July, 1914. Commencement address: Professional Ethics, by Dr. Rossiter W. Raymond.

Vol. IX, No. 3. Oct., 1914. Electroscopes and Methods of Radioactive Measurements, by L. F. Miller.

Vol. IX, No. 4. Jan., 1915. Preliminary Report of the Cresson Gold Strike at Cripple Creek, Colorado, by H. B. Patton and H. J. Wolf.

The Cyanide Industry, Its Present Status and Future Development, by F. W. Traphagen.

Vol. X, No. 1. April, 1915. Book of Views.

Vol. X, No. 2. July, 1915. Commencement address: Epochs in Science, by Lucien I. Blake.

Vol. X, No. 3. Oct., 1915. The Forty-second Annual Opening, address by Gov. George A. Carlson.

The Potash Deposits of the Sand Hills Region of Northwestern Nebraska, by Victor Ziegler.

System of Heat Distribution, by R. S. Hawley.

Address on Rare Metals, Tungsten, by H. Fleck.

The Cost of Power in Isolated Plants, by R. S. Hawley.

Oil Flotation at the Colorado School of Mines, by F. W. Traphagen.

The Mineral Resources of Texas, by V. Ziegler.

Vol. X, No. 4. Dec., 1915. The Colorado Workmen's Compensation Act, by Wayne C. Williams.

Safety and Conservation in Life Insurance, by M. G. Hodnette.

The Insurance Angle of our Workmen's Compensation Act, by Newcomb Cleveland.

The Interpretation and Use of Financial Reports.

Vol. XI, No. 1. Jan., 1916. Book of Views.

Vol. XI, No. 2. April, 1916. Flotation Experiments, by W. H. Wright.

Vol. XI, No. 3. July, 1916. Commencement Address: The Problem of Efficiency, by James R. Findley.

Notes on the Survey of a Large Tract of Land, by William R. Chedsey.

Geological Sections in the Vicinity of Golden, by L. Ehnbom.

A Study of the Compressor Indicator Diagram, by F. W. Lucht.

Heat Loss thru Buildings and Building Material, by R. S. Hawley.

A Treatise on Molybdenum, by Herman Fleck.

Vol. XI, No. 4. Oct., 1916. Tube Milling Coke, by G. J. Young.

The Spectroscope and Spectroscopic Analysis, by L. F. Miller.

The Civic Duties and Opportunities of the Engineer, by H. C. Parmalee.

Vol. XII, No. 1. Jan., 1917. Catalog edition, 1917.

Vol. XII, No. 2. April, 1917. Foothills Structure in Northern Colorado, by Victor Ziegler.

Vol. XII, No. 3. July, 1917. The Experimental Ore Dressing and Metallurgical Plant of the Colorado School of Mines, by Victor C. Alderson.

Vol. XII, No. 4. Oct., 1917. Book of Views.

Vol. XIII, No. 1. Jan., 1918. Catalog edition, 1918.

Vol. XIII, No. 2. April, 1918. The Oil Shale Industry. . . . Nature, Origin, and Distribution of Oil Shale, by Victor C. Alderson.

Vol. XIII, No. 3. July, 1918. Common Methods of Determining Latitude and Azimuth Useful to Engineers and Surveyors, compiled by Harry J. Wolf.

Vol. XIII, No. 4. Oct., 1918. Colorado's Future as an Oil Producer, by Victor Ziegler.

Vol. XIV, No. 1. Jan., 1919. Catalog edition, 1919.

Vol. XIV, No. 2. April, 1919. Book of Views.

Vol. XIV, No. 3. July, 1919. The Cripple Creek District of Colorado. . . . Resurvey Colorado School of Mines—collaborators being V. C. Alderson, I. A. Palmer, Capt. James T. Smith, F. M. Van Tuyl and H. J. Wolf.

Vol. XIV, No. 4. Oct., 1919. The Oil Shale Industry . . . of Colorado, by Victor C. Alderson.

The Composition of Oil Shale and Shale Oil, by C. W. Botkin.

The Production of Shale Oil, by John C. Williams.

Vol. XV, No. 1. Jan., 1920. Catalog edition. 1920:

Vol. XV, No. 2. April, 1920. The Refining of Crude Petroleum, by Albert H. Low.

Some Observations Relative to Shale Oil, by Albert H. Low.

Vol. XV, No. 3. July, 1920. Book of Views.

Vol. XV, No. 4. Oct., 1920. The Oil Shale Industry in Scotland and England, by Victor C. Alderson.

Directory of Scottish and English Oil Shale Retorts, by Victor C. Alderson.

Vol. XV, No. 4 Sup. Oct., 1920. A Directory of Oil Shale Retorts, by Victor C. Alderson.

Bibliography of Publications on Oil Shale, by Victor C. Alderson.

Vol. XVI, No. 1. Jan., 1921. Catalog edition, 1921.

Vol. XVI, No. 2. April, 1921. The Present Status of the Oil Shale Industry, by Victor C. Alderson.

The Colorado School of Mines Method for the Distillation of Oil Shale, by A. H. Low.

A Study of the Saturated and Unsaturated Compounds of Shale Oils, by C. W. Botkin.

Oil Shale Industry—Selected Bibliography, by Victor C. Alderson.

Vol. XVI, No. 3. July, 1921. Commencement address: The Twentieth Century Engineer, by Frederick Laist.

Vol. XVI, No. 4. Oct., 1921. A Symposium of Studies and Researches in the Oil Shale Industry. . . . Chemical Engineering and Economics in Shale Oil Production. . . . Studies in Colorado Shale Oil, Pt. I–III. . . . Action of Steam and Gases on Yields of Ammonia from Carbonization of Oil Shales and Coal, by Arthur J. Franks, asst. by J. P. Bacca and C. P. Hackett.

Oil Shale Bibliography of Recent Articles, by Victor C. Alderson.

Vol. XVI, No. 4 Sup. Oct., 1921. American Mining Congress, Chicago, Oct. 17–21, 1921. . . . National Oil Shale Conference.

Recent World Wide Progress in Oil Shale Development, by Victor C. Alderson.

Address by S. E. Barnwell, "Oil Shale."

Some Notes on the Production of Oil from Shale, by Lewis B. Skinner.

Oil Shales, by J. A. Ede (National Oil Shale Conference).

Vol. XVII, No. 1. Jan., 1922. Catalog edition, 1922.

Vol. XVII, No. 1 Sup. Jan., 1922. Book of Views.

Vol. XVII, No. 2. April, 1922. Education of a Mining Engineer, by Victor C. Alderson.

Vol. XVII, No. 3. July, 1922. Commercial Oil Shale—What Is It?, by Victor C. Alderson.

Esthonian Prizes for Oil Shale Furnaces, by Victor C. Alderson.

Oil Shale Bibliography, July, 1922, by Victor C. Alderson.

Vol. XVII, No. 4. Oct., 1922. Oil Shale of Kentucky, by Victor C. Alderson.

Oil Shale in Russia, by Victor C. Alderson.

Vol. XVII, No. 4 Sup. a. Oct., 1922. Preliminary Study of the Organic Matter of Colorado Oil Shales, by Arthur J. Franks and B. D. Goodier.

Vol. XVII, No. 4 Sup. b. Oct., 1922. American Mining Congress, Cleveland, Ohio, Oct. 9–14, 1922—National Oil Shale Conference. Including oil shale exhibit from the Colorado School of Mines. Mining of the Oil Shales, by William C. Russell.

Vol. XVIII, No. 1. Jan., 1923. Catalog edition, 1923–25.

Vol. XVIII, No. 1 Sup. a. Jan., 1923. A Dissertation . . . Chemical Examination of the Organic Matter in Oil Shales, by Ralph H. McKee and Ralph T. Goodwin.

Vol. XVIII, No. 1 Sup. b. Jan., 1923. Oil Shale—A Résumé for 1922, by Victor C. Alderson.

Oil Shale Bibliography for 1922, by Victor C. Alderson.

Vol. XVIII, No. 2. April, 1923. The Education of a Mining Engineer, by Victor C. Alderson.

Vol. XVIII, No. 3. July, 1923. The Destructive Distillation of Oil Shale: A thesis submitted to the faculty of the college of mining at the University of California, for B.S. by Robert J. G. Stewart and John Trenchard, April 30, 1923.

Vol. XVIII, No. 4. Oct., 1923. National Oil Shale Conference, in connection with the American Mining Congress, Milwaukee, Wis., Sept. 24–29, 1923.

Vol. XIX, No. 1. Jan., 1924. The Oil Shale Industry: A Résumé for 1923, by Victor C. Alderson.

Book of Views.

Vol. XIX, No. 2. April, 1924. Investigation of Oil Shale Kerogen by the Fractionation of the Primary Bitumen in High Vacuum and by Organic Extractions: A thesis presented to the department of chemistry of Leland Stanford Junior Univ., June, 1923, in partial fulfillment for the degree of M.A. by Chester Oklahoma Blackburn.

Vol. XIX, No. 3. July, 1924. The Trumble Oil Shale Cycle Distillation Plant, by Victor C. Alderson.

Vol. XIX, No. 4. Oct., 1924. National Oil Shale Conference, Sacramento, Calif., Victor C. Alderson, Chairman.

Vol. XX, No. 1. Jan., 1925. Catalog edition, 1925–27.

Vol. XX, No. 1 Sup. a. Jan., 1925. The Oil Shale Industry: A Résumé for 1924, by Victor C. Alderson.

Vol. XX, No. 1 Sup. b. Jan., 1925. Distillation of New Albany Oil Shales by A. W. Homberger and F. M. Shipman, department of chemistry, University of Louisville, Louisville, Kentucky.

Vol. XX, No. 1 Sup. c. Jan., 1925. Book of Views.

Vol. XX, No. 2. April, 1925. Colorado Oil Shale, by Victor C. Alderson.

Vol. XX, No. 3. July, 1925. The Geology of the Golden Area, Colorado, by J. Harlan Johnson.

Vol. XX, No. 4. Oct., 1925. Bibliography of Colorado Maps, compiled by J. Harlan Johnson.

Vol. XXI, No. 1. Jan., 1926. Catalog edition, 1926–27.

Vol. XXI, No. 2. April, 1926. The Trend of Flotation, by Arthur J. Weinig and Irving A. Palmer.

Vol. XXI, No. 3. July, 1926. Bibliography of the Geology and Related Subjects of Northwestern Colorado (Revised to June 1, 1926). Compiled by J. Harlan Johnson.

Vol. XXI, No. 4. Oct., 1926. Building Conditions at the Colorado State Institutions of Higher Learning. Prepared by Ralph L. Crosman.

Vol. XXI, No. 4 Sup. a. Oct., 1926. Maintenance Conditions at the Colorado State Institutions of Higher Learning. Prepared by Ralph L. Crosman.

Vol. XXII, No. 1. Jan., 1927. Catalog edition, 1927–28.

Vol. XXII, No. 1 Sup. a. Jan., 1927. Book of Views.

Vol. XXII, No. 2. April, 1927. Petroleum, a Selected Bibliography, by Mary E. Hoyt.

Vol. XXII, No. 3. July, 1927. Commencement address: Mining and Civilization, by T. A. Rickard.

Vol. XXII, No. 3 Sup. a. July, 1927. Summer session, 1927.

Vol. XXII, No. 4. Oct., 1927. Bibliography of the Geology of North Central Colorado, by J. Harlan Johnson.

Vol. XXIII, No. 1. Jan., 1928. The Electrodeposition of Zinc from Ammoniacal Carbonate Solutions, by Thomas P. Campbell.

Vol. XXIII, No. 1 Sup. a. Jan., 1928. Summer session, 1928.

Vol. XXIII, No. 2. April, 1928. The Trend of Flotation (second edition) by A. J. Weinig and Irving A. Palmer.

Vol. XXIII, No. 3. July, 1928. Index of Publications of the Colorado School of Mines, by Montgomery R. Budd.

Vol. XXIII, No. 3 Sup. a. July, 1928. Studies in Colorado Coals, by Clark B. Carpenter and W. A. Manuel.

Vol. XXIII, No. 4. Oct., 1928. Bibliography of the Geology of South Central Colorado, by J. Harlan Johnson.

Vol. XXIV, No. 1. March, 1929. Geophysical Methods of Prospecting, Principles and Recent Successes, by C. A. Heiland. Price $1.00.

Vol. XXIV, No. 2. April, 1929. Catalog edition, 1929–30.

Vol. XXIV, No. 2 Sup. a. April, 1929. Summer session, 1929.

Vol. XXIV, No. 3. July, 1929. Book of Views.

Vol. XXIV, No. 4. Oct., 1929. Trend of Flotation (third edition revised) by A. J. Weinig and Irving A. Palmer. Price 25c.

Vol. XXV, No. 1. Jan., 1930. Catalog edition, 1930–1931.

Vol. XXV, No. 1 Sup. a. Jan., 1930. Summer session, 1930.

Vol. XXV, No. 2. April, 1930. The Experimental Mine, by J. Burns Read and James Underhill.

Vol. XXV, No. 2 Sup. a. April, 1930. Field Work in Geology at the Colorado School of Mines, by Wm. P. Huleatt.

Vol. XXV, No. 2 Sup. b. April, 1930. Field Work at the Colorado School of Mines.

Vol. XXV, No. 3. July, 1930. Geology of the Golden Area (second edition revised) by J. Harlan Johnson.

UNIVERSITY OF DENVER, Denver. Frederick Maurice Hunter, Chancellor; R. E. Nyswander, Dean of Electrical Engineering; W. D. Engle, Dean of Chemical Engineering.

No engineering research organization. Research carried on in engineering departments.

Funds Available for 1929–30: Allotment by University authorities, $2000; grants from other sources, $2500.

Employees for 1929–30: Part time, 9.

Channels of Publication: The technical press.

CONNECTICUT

YALE UNIVERSITY, New Haven. James Roland Angell, President; Charles H. Warren, Dean of the Sheffield Scientific School.

Engineering Research Organization: Each of the engineering departments looks after its own research. Except for certain men who are research assistants, no appointments are purely for research. All members of the staff are expected to be engaged in engineering research or professional engineering work of some kind.

Funds Available for 1929–30: No distinct appropriation for research work. Each departmental budget does, however, carry a certain sum that is devoted to such purposes. Not infrequently sums of money, running anywhere from $1000 to several thousand dollars, are contributed by industrial concerns or other agencies to promote certain types of research.

Channels of Publication: Proceedings of engineering societies, the technical press, and *Yale Scientific Magazine.*

Live Research Projects

Department of Chemical Engineering

1. Studies on the Behavior of Coal under Accurately Known Conditions. The manufacture of an artificial anthracite from bituminous coal, the conversion of coal to oil, the complete gasification of coal, and many similar problems require that there be secured much better and more comprehensive information regarding the behavior of coal under various conditions. Professor Curtis and Mr. Lloyd, with two graduate and two undergraduate students.

2. Catalytic High Pressure Gas Reactions. Processes involving reactions of this sort are now being applied in the commercial production of ammonia and of methanol and in the manufacture of motor fuel from coal. It is probable that many other processes involving catalyzed gas reactions at high pressures

will come into use in the near future. The field is an important one for research, and one for which, because of the difficulties and expense involved, but few university laboratories are equipped. Professor Dodge, aided by one graduate student and one research assistant.

3. Disposal of Factory Waste Materials. Mr. Copson in cooperation with the Connecticut State Water Commission. One important problem in waste disposal has been solved in the past year and another is now in hand.

4. Miscellaneous. Several minor problems are being studied by graduate and undergraduate students under faculty supervision. Amongst these are:

(*a*) Interfacial Surface Tension Effects Between Solids and Liquids.
(*b*) Development of Colors on Metal Surfaces.
(*c*) Solubility of Gases in Liquids under High Pressures.
(*d*) Evaporation of Liquids by Hot Gases.
(*e*) Absorption of Gases by Liquids in Absorption Towers.
(*f*) Laws Governing Flow of Gases Through Columns of Broken Solids.

Department of Civil Engineering

J. C. Tracy:

"Stresses—Statically Determined." A book of 462 double pages—result of studies and investigations during past ten years.

R. S. Kirby:

1. Yale University Press published September, 1929, "Fifth Study of Motor Vehicle Accidents in the State of Connecticut." Hartley Corporation paid for the study, and State Motor Vehicle Department furnished data. F. R. Hughes and D. F. Grant assisted. 50 page booklet with 36 diagrams.

2. Read paper, February 19, 1929, at annual meeting of the Connecticut Society of Civil Engineers on "Some Early American Civil Engineers and Surveyors." About 4000 words, illustrated with thirty slides.

3. Has just completed article on "Motor Vehicle Accidents" for *Encyclopedia of the Social Sciences* (Dr. Edwin R. A. Seligman of Columbia University, Editor). More than 3000 words. Data for it gathered from official sources in this country, in England, Germany, and France by means of personal interviews and correspondence. Aims to give a picture of the situation from an international point of view.

4. Progress on book covering some phases of Civil Engineering History. Began early in 1928. Spent some months abroad on it during Sabbatical half-year beginning July, 1928. Prof. Laurson now assisting. Nearly 60,000 words, or perhaps two-thirds done. Hopes to have it complete in fall.

Theodore Crane:

As supervising editor of the General Building Contractor, published by the F. W. Dodge Corporation, planning to use the facilities of this organization on research work pertaining to the construction problems and economic questions in the building industry. The first subjects for research are:

1. The Effect of the Five-Day Week on the Building Industry. From the viewpoint of the builder, the mechanics and the owner.

2. The Value of Bonus Systems and Craftsmanship Awards.

3. Accident Prevention During Construction. Much has already been written on this subject, but practice is not by any means standardized throughout the country.

4. Designing and Constructing Rain-Tight Walls.

5. Welding Structural Steel for Building Frames.

D. P. Krynine:

Engaged in research work pertaining to soil mechanics. Included in this work are investigations for the State of Connecticut of soil conditions with special reference to highway construction in different parts of the State.

Department of Electrical Engineering

Charles F. Scott:

As Chairman of the Board of Investigation and Coordination of the Society for the Promotion of Engineering Education has in press a report which marks the culmination of a comprehensive study directed to the improvement of engineering education undertaken in 1923. Has recently published an article in the *Journal of Higher Education* on the subject of engineering education.

Hubert M. Turner:

Has been engaged during past two years investigating iron-cored circuits and has published the following papers—"The Constant Impedance Method of Measuring the Inductance of Choke Coils," *Proc. I. R. E.*, Nov., 1928 (this method has been adopted by several engineering laboratories); "Inductance as Affected by the Initial Magnetic State, Air-Gap and Superposed Currents" presented at a Joint Meeting of the Institute of Radio Engineers and the International Union of Scientific Radio Telegraphy in Washington, May, 1929, and published in the *Proc. I. R. E.*, Oct., 1929; "The Characteristics of Audio-Frequency Transformers" presented before the Radio Club of America, April, 1929, and published in their Proceedings, Sept., 1929, and reprinted in *Radio Broadcast*, Nov., 1929. A paper on "Transient Current in Transformers" has recently been completed. Several other investigations are under way extending this work.

Archer E. Knowlton and T. A. Abbott:

Investigation of methods of measuring reactance power in alternating current circuits.

R. G. Warner:

Rate research in connection with the rates to be charged for street lighting.

W. B. Hall:

Has developed a bridge balancing device for factory use and has also been studying electrolytic condensers.

F. T. McNamara:

Has completed the development of an electron tube micro-wattmeter for measuring small values of power in communication circuits and cable research. Is developing a new method of modulation which appears to have considerable merit.

O. P. Cleaver:

Working on an improved method of controlling the intensity and color of theater lighting.

W. J. Holman, Jr.:

Making a study of the alternating current single phase shunt motor, investigating it theoretically and experimentally.

Department of Engineering Mechanics

William J. Cox:

1. Spent the summer of 1929 as Research Associate of the U. S. Bureau of Standards in Washington; was engaged in arranging and interpreting the results of a long series of experiments on the properties of sheet duralumin, with particular reference to its behavior under "fatigue" or repeated stresses. This study will probably be published in the Research Journal of the Bureau.

2. Is studying the trends in automobile fatalities in the United States in connection with the National Conference on Street and Highway Safety, of which he is a member. At the last Annual Meeting of the American Society of Civil Engineers he was awarded the Collingwood Prize for his paper entitled "Automobile Hazard in Cities and its Reduction," published in the Transactions of the Society, Vol. 92, 1928.

Philip G. Laurson:

Is engaged on a series of investigations on electrical welds in structural steel. This is being done in cooperation with the Structural Welding Committee of the American Bureau of Welding, of which the Chief Engineer of the American Bridge Company is chairman. In this connection Mr. Laurson is working with Professor Tilden (of this Department) who is a member of the Fundamental Research Committee of the American Bureau of Welding, in the preparation of a program for welding research to be carried on at Yale. The American Bureau of Welding will finance this work.

George W. Colton:

Is making an investigation of the thermodynamic performance of a certain operating cycle for refrigerating and air conditioning equipment; and also a study of stress distribution in certain machine elements.

Charles J. Tilden:

1. Has cooperated for several years past with William P. Eno in studies of highway traffic regulation. These studies culminated in Mr. Eno's fifth book on the subject "Simplification of Highway Traffic," the appendix of which (sixty-four pages) was written by Mr. Tilden.

2. Member of the National Conference on Highway Safety in Washington and has continued his work as Highway Research Specialist for the Bureau of Public Roads. A Member of the Executive Committee of the Highway Research Board of the National Research Council.

Department of Mechanical Engineering

H. L. Seward:

As a member of the committee appointed by the Secretary of Commerce (Col. Lamont) has been studying Marine Boiler Codes with a view to presenting to the industry a unified and coordinated code in place of the four separate codes with which it is now confronted. Design rules for steam turbines, pressure piping, and electrical machinery have been started. Plans for new ships are being studied and suggestions made.

W. J. Wohlenberg:

1. Study of heat transfer in convection zone of boilers taking into account the radiation absorption which occurs in zones where the gas temperatures are high.

2. An attempt is being made to analyze the several factors which may play an important part in the progress of combustion under conditions of what are known as turbulent firing.

3. Analysis of the conditions which control the radiation emission at the space time points where groups of atoms enter into reaction to form the product molecule. This study was undertaken to see if there might possibly be anything of a special nature for this particular part of the total radiation which occurs in a furnace cavity.

E. O. Waters:

1. Further analysis of stresses in steel pipe flanges and fittings, preparatory to the adoption of standard proportions.

2. General plant engineering for H. G. Thompson & Son Co., comprising the design of labor-saving equipment, and performance tests of product.

L. C. Lichty:

1. A theoretical investigation of Flame Front Positions in the Combustion Chamber of Internal Combustion Engines. This investigation takes into account the actual air-fuel mixture with variable specific heats and chemical equilibrium. The results will present a picture of the positions of the flame front

for any given portion burned, compression ratio, and heat loss during the process, and also show the effect of the various factors, such as pressure, temperature, heat loss and dilution of charge upon flame front positions.

2. An investigation of Detonation in Internal Combustion Engines in a cylinder head designed for detonation control. This is an experimental investigation proceeding along a line almost diametrically opposite to trend of thought on the subject.

L. E. Seeley:

1. Study of heat emission from tubes placed in a wind tunnel. One year was devoted to a study of a variety of single tubes, many with extended surfaces. This year the study is being carried on with two tubes to see whether the position of one tube relative to the other will increase or decrease the emission of heat from each tube.

2. Study of operating characteristics of oil burners and heating boilers. This is a cooperative project and may continue for some time.

E. H. Lockwood:

1. Investigations of automobile power plant and transmission performance using the rear wheel dynamometer have been continued during the year. Several new designs of motors and accessories, such as carburetors for burning fuel oil in automobile engines, improved types of tires, radiators, etc., have been tested.

2. Several forms of extended surface (tube and fin type), house-heating radiators have been investigated. Some fundamental problems in heat transfer from steam to air through metal walls have been undertaken.

Publications *

Department of Chemical Engineering

1929–1930

1. The Development of the Air-Nitrogen Industry in the United States, by Harry A. Curtis. Paper No. 326 at the World Engineering Congress, Tokio, October, 1929.

2. Decomposition of Methanol over Catalysts Composed of Oxides of Zinc and Chromium, by John R. Huffman and Barnett F. Dodge. *Industrial and Engineering Chemistry, 21,* 1056 (1929).

3. Note on the Methanol Equilibrium, by Barnett F. Dodge. *Industrial and Engineering Chemistry, 22,* 89 (1930).

4. A Study of Certain American Coals at Temperatures Near Their Softening Points, by Alpheus M. Ball and Harry A. Curtis. *Industrial and Engineering Chemistry, 22,* 137 (1930).

5. A Process for the Disposal of Waste Kier Liquor, by Raymond L. Copson and Harry A. Curtis. *Chemical and Metallurgical Engineering, 37,* 167 (1930).

6. New Criterion for Coking Value of Coal, by T. C. Lloyd. *Chemical and Metallurgical Engineering, 37,* 169 (1930).

7. Coal, Chapter XXXII in "Annual Survey of American Chemistry," Chemical Catalog Co., New York, 1930.

Department of Mechanical Engineering

1925–1930

1. Fuel Conservation in U. S. Government Merchant Marine Fleet, by H. L. Seward. *Mechanical Engineering,* October, 1926. Discussion and closure *Mechanical Engineering,* January, 1927.

* See also notes on publications under "Live Research Projects."

2. Results of Automobile Truck Transmission Efficiency Experiments at the Mason Laboratory during 1926, by L. M. Porter. Presented before the New Haven Section, A. S. M. E., November 19, 1926.

3. Influence of Radiation in Coal Fire Furnaces on Boiler Surface Requirements and a Simplified Method for Its Calculation, by W. J. Wohlenberg (with E. L. Lindseth). Presented at annual meeting, A. S. M. E., December, 1926.

4. Machine Design Problems (118 pages), by E. O. Waters (with S. J. Berard), January, 1927.

5. High Pressure Steam in Marine Power Plants, by H. L. Seward. *Marine Journal*, February 26, 1927.

6. Apparatus to Aid Navigation Instruction, by H. L. Seward. *Marine Journal*, April 1, 1927.

7. Strength of Pipe Flanges, by E. O. Waters (with J. H. Taylor). Presented at A. S. M. E. Spring Meeting, May, 1927.

8. The Cause and Effect of Tire Slip, by E. H. Lockwood. *Yale Scientific Magazine*, May, 1927.

9. Some Fundamental Considerations in the Design of Boiler Furnaces, by W. J. Wohlenberg (with F. W. Brooks). Presented at the Erie Regional Power Meeting, A. S. M. E., June 3–4, 1927.

10. A Survey of Modern Marine Engineering, by H. L. Seward. *Yale Scientific Magazine*, March, 1928.

11. High Pressure Combustion, by L. C. Lichty. *Yale Scientific Magazine*, March, 1928.

12. How It Feels to be an Engineer on the Steamship Leviathan, by H. L. Seward. *Marine Age*, May 1, 1928.

13. Paper on the general subject of automobile braking systems, their relations to safety questions involved, and some of the legislative and administrative questions requiring attention, prepared by E. H. Lockwood, in cooperation with Robbins B. Stoeckel, Commissioner of Motor Vehicles of the State of Connecticut, as a result of a special investigation of the brake leverage system on various cars conducted by H. W. Best, and delivered at the Annual Meeting of the Society of Automotive Engineers in Quebec, June, 1928.

14. The Influence of Coal Type on Radiation and Boiler Furnaces, by W. J. Wohlenberg, delivered at the Annual Meeting of A. S. M. E., December, 1928.

15. Graphical Methods for Least Square Problems, E. O. Waters, delivered at the Annual Meeting of the A. S. M. E., December, 1928; published in revised form in *Aviation*, Vol. II, No. 2.

16. High Compression and Anti-Knock Fuels, by L. C. Lichty, delivered before Annual Meeting, S. A. E., Detroit, January, 1929.

17. Boiler Ratings, by L. E. Seeley, presented, January, 1929, New York Chapter, American Society of Heating & Ventilating Engineers.

18. Discussion of a paper by A. G. M. Michell on Progress in Fluid Film Lubrication, by E. O. Waters at meeting of Metropolitan Section, A. S. M. E., May 7, 1929.

19. Written discussion of paper by A. L. Kimball, "Vibration Damping, Including the Case of Solid Friction," before Applied Mechanics Division, Rochester Meeting, A. S. M. E., May, 1929, by E. O. Waters.

20. Mixture Distribution in Gasoline Engines, by H. W. Best, delivered before S. A. E., in Saranac, June, 1929.

21. Lectures before the summer conference of mechanical engineering teachers, Purdue, July, 1929, by W. J. Wohlenberg. (1) Fuels and Combustion. (2) Heat Reactions in the Boiler Furnace. (3) Economics of Heat Transfer.

22. Lectures delivered at Summer School of Mechanical Engineering Teachers, Purdue, July, 1929, by Professor S. W. Dudley:

(a) Organization of Courses in Mechanical Engineering Subjects for Non-Mechanical Engineers.

(b) Training of Designers—Methods of Training.
(c) The Mechanical Engineering Laboratory Course.
(d) Comparative Tests of Lubricants for a Rotary Ammonia Compressor, by E. J. Tavanlar, Senior student in Mechanical Engineering, published in Vol. 19, No. 2, *Refrigerating Engineering*, February, 1930—awarded third prize in student contest by American Society of Refrigerating Engineers; also appeared as Ammonia Compressor Lubrication Tests in the March, 1930, issue of *Yale Scientific Magazine*.

23. Marine Engineering and Design, by H. L. Seward, World Engineering Conference in Tokyo, fall of 1929.

24. A Study of the Cutting Action of Saw Teeth, by E. O. Waters, based upon investigations made for the H. G. Thompson & Son Co., of New Haven.

25. Discussion of A. S. M. E. paper by Wahl & Lobo, Stresses and Deflection in Flat Circular Plates with Central Holes, presented at Akron Meeting, A. S. M. E., October 21, 1929, by E. O. Waters.

26. Marine Industry Proceedings, Ninth Annual Middlewest Foreign Trade and Merchant Marine Conference, Milwaukee, November 18, 1929.

27. Fuels and Combustion, by W. J. Wohlenberg, *Journal* of Society for Promotion of Engineering Education, December, 1929.

28. American Bureau of Shipping Bulletin, Industrializing the Marine Industry, by H. L. Seward.

29. Progress in Automatic Train Control, by S. W. Dudley, *Yale Scientific Magazine*, January, 1930.

30. Tendencies in Marine Engineering Design, by H. L. Seward, *Yale Scientific Magazine*, January, 1930.

31. Combustion Radiation and the Planck Quantum Theory, submitted to A. S. M. E. by W. J. Wohlenberg, April, 1930, for publication in *Mechanical Engineering*, or *Transactions*, possibly in serial form.

32. Internal Combustion Engines, by Streeter & Lichty, Third Edition, revised, by L. C. Lichty.

33. High Pressure Combustion, by L. C. Lichty. Mechanical Section, *Proceedings*, A. S. M. E.

34. Revision of Smallwood's "Mechanical Laboratory Methods of Testing Machines and Instruments" now under way, by F. W. Keator.

35. Flame Front Position in Internal Combustion Engines, in preparation, by L. C. Lichty.

Research Investigations in the Mason Laboratory 1925–1926

1. Strength and Deflection of Pipe Flanges and Development of Corresponding Formulae. E. O. Waters for the American Spiral Pipe Works, Chicago, Ill.

2. Combustion of Gases under High Pressures. L. C. Lichty.

3. Study of Detonation in a High Compression Automobile Engine. L. C. Lichty, F. W. Keator, and L. M. Porter.

4. Motorcycle Vibration Studies. L. C. Lichty for the Indian Motorcycle Company, Springfield, Mass.

5. Tractive Resistance of Vehicles. E. H. Lockwood.

6. Slippage and Tractive Resistance of Automobile Tires. E. H. Lockwood.

7. Power and Efficiency of Automobiles of Various Makes. E. H. Lockwood.

8. Steam Radiator Tests. E. H. Lockwood for the H. B. Smith Company, Westfield, Mass.

9. Fuel Investigations. E. H. Lockwood and L. E. Seeley for the H. B. Smith Company, Westfield, Mass.

10. Design and Operation of House Heating Boilers. L. E. Seeley for the H. B. Smith Company, Westfield, Mass.

11. Design and Calibration of a Supersensitive Pressure Regulator. W. J. Wohlenberg and A. B. Stickney. M. E. Thesis.

12. Heat Transfer, Water to Water. W. J. Wohlenberg and J. Y. Parce. M. E. Thesis.

13. Auto Truck Transmission Efficiency. E. H. Lockwood and L. M. Porter. M. E. Thesis.

1926–1927

1. Standardization of Steam Radiator Test Room and Test Code. E. H. Lockwood and L. E. Seeley in cooperation with American Radiator Company for Radiator Research Committee, A. S. H. & V. E.

2. Air Resistance of Automobiles. E. H. Lockwood and others in cooperation with General Motors Corporation for General Motors Corporation, Flint, Michigan.

3. Combustion of Artificial Fuels in No. 34 Mills Boiler. L. E. Seeley for Calco Chemical Company, Bound Brook, New Jersey.

4. Boiler Rating Code Studies. L. E. Seeley for H. B. Smith Company, Westfield, Mass.

5. Heating Boiler Ratings. L. E. Seeley for Rating Code Committee of A. S. H. & V. E.

6. Combustion of Gases under High Pressures (continued). L. C. Lichty.

7. Construction and Calibration of Improved Supersensitive Pressure Regulator. W. J. Wohlenberg and J. Y. Parce. M. E. Thesis.

8. Economic Performance Studies of 10″ x 13″ Skinner Unaflow Engine. W. F. Hamilton and E. H. Lockwood. M. E. Thesis.

9. Study of Automobile Tire Characteristics. E. H. Lockwood and L. C. Lichty for Fisk Rubber Company, Chicopee Falls, Mass.

10. Strength and Deflection of Pipe Flanges, with Development of Formulae and Diagrams. E. O. Waters for American Spiral Pipe Works, Chicago, Ill.

1927–1928

1. Theoretical Investigation of Circulation in Furnace with Water Walls. W. J. Wohlenberg.

2. Investigation Work on Coal Pulverization. W. J. Wohlenberg.

3. Optical Indicator for Internal Combustion Engines—built at Mason Laboratory (preliminary statement of results given at S. A. E. meeting, Detroit, Jan., 1928). L. C. Lichty.

4. Study of Detonation in Internal Combustion Engines. L. C. Lichty.

5. Air Resistance of Eighteen Typical Automobiles. E. H. Lockwood and M. F. Smith.

6. Preliminary Studies of Vibration Machine for Investigations of Riding Qualities. F. W. Keator.

1928–1929

1. Oil Burner Devices. Research program in cooperation with the A. S. H. & V. E. L. E. Seeley.

2. Continuation of Air and Fuel Metering of Chrysler Gasoline Engine. For check on gas analysis calculations. E. H. Lockwood.

3. Design, Construction, and Testing of an Automatic Stoker. To be used in connection with H. B. Smith Company Boiler. H. H. Dedo. Thesis.

4. Heat Transfer from Extended Surface Radiator Elements. C. S. Hamner. Thesis.

5. Radiation to Water-Cooled Tubes Bounding Furnace Cavities. G. P. Vye. Thesis.

6. Circulation in Water-Cooled Furnace Walls. E. D. Grimison. Thesis.
7. Experimental Study of Detonation. L. C. Lichty.
8. Studies in the Field of Combustion and Radiation. W. J. Wohlenberg.
9. A Study of the Air Resistance of Automobiles. H. W. Best.

DISTRICT OF COLUMBIA

THE CATHOLIC UNIVERSITY OF AMERICA, Washington. James Hugh Ryan, Rector; Hardee Chambliss, Dean of the School of Engineering.

No engineering research organization.

Live Research Projects

1. A Method of Indicating the Speed of Induction Motors in the Field. T. J. MacKavanagh.
2. Wind Tunnel Tests of Aeroplane Propellers and Wings. Louis Crook.
3. Impeller Design. George A. Weschler.
4. Heating and Ventilating Equipment and Systems. George A. Weschler.
5. Lumber Investigations. Hardee Chambliss.

GEORGE WASHINGTON UNIVERSITY, Washington. Cloyd Heck Marvin, President; John Raymond Lapham, Dean of the School of Engineering.

No engineering research organization.

No engineering research reported.

HOWARD UNIVERSITY, Washington. Mordecai W. Johnson, President; Lewis K. Downing, Acting Dean of the College of Applied Science.

No engineering research organization.

No engineering research reported.

GEORGIA

UNIVERSITY OF GEORGIA, Athens. Charles M. Snelling, Chancellor; Charles M. Strahan, Professor of Civil Engineering.

No engineering research organization.

No funds allotted for engineering research.

Engineering Research Bulletin Published

Research Work on Semi-Gravel, Top Soil, Sand-Clay, and Other Road Materials in Georgia, by C. M. Strahan. Bulletin of the University of Georgia, Vol. XXII, No. 5a, June, 1922.

Live Research Project

Study of Sand-Clay, Semi-Gravel, and Similar Materials for Road Betterment. C. M. Strahan.

A report on five years study of twenty-nine Federal Aid Projects in Georgia conducted for the Georgia State Highway Department and the U. S. Bureau of

Public Roads was published in the September, 1929, *Public Roads* (issued by the U. S. Bureau of Public Roads).

GEORGIA SCHOOL OF TECHNOLOGY, Atlanta. Marion Luther Brittain, President.

No engineering research organization.

No engineering research projects reported, but several professors reported doing some research in Ceramics, Chemistry, etc.

ILLINOIS

ARMOUR INSTITUTE OF TECHNOLOGY, Chicago. Howard M. Raymond, President; John C. Penn, Dean of Engineering.

No engineering research organization, but many projects of a research nature in progress.

Discontinued or Completed Engineering Research Projects

which resulted in valuable data not published in bulletins or circulars, but available.

1. Positive Coesium Ions in Hydrogen and Helium. J. S. Thompson. *Physical Review*, December, 1929.
2. The Motion of Positive Ions in Gases. J. S. Thompson. *Physical Review*, May 15, 1930.
3. The Quartz Spectrograph. Thomas E. Doubt. *Laboratories' Data*, Underwriters' Laboratories, Vol. X, No. 5, May, 1929.
4. Fume Hazard of Cellulose Acetate X-Ray Film. C. A. Tibbals. *Laboratories' Data*, October, 1929.
5. Forestalling Industry's Fire, Explosion, and Poison Hazards. C. A. Tibbals. *Chemical & Metallurgical Engineering*, Vol. 37, No. 3, March, 1930.
6. Analysis of Swedish Methods in Heat Transmission Tests of Building Materials. J. C. Peebles. *Heating, Piping, and Air Conditioning*, October and December, 1929.
7. Theory Underlying Surface Tension Measurements. B. B. Freud. *Journal of American Chemical Society*, May, 1930.
8. Theory of Ring Method for Determination of Surface Tension. B. B. Freud. *Science*, April, 1930.
9. The Measurement of the Flow of Air Through Registers and Grills. L. E. Davies. *Heating, Piping and Air Conditioning*, January, 1930. (Reprinted in bulletin form.)

LEWIS INSTITUTE, Chicago. George N. Carman, Director; John D. Nies, Dean of Engineering; George D. King, Professor in charge, Building Materials Research Laboratory.

Engineering Research Organization: Building Materials Research Laboratory, established by the Board of Trustees, 1916. Now conducted by the United States Gypsum Company in cooperation with the Institute. The staff consists of approximately ten men under the direction of the professor in charge.

NORTHWESTERN UNIVERSITY, Evanston. Walter Dill Scott, President; Wm. Chas. Bauer, Dean of the School of Engineering.

No engineering research organization. Special research is carried on by various professors.

Funds Available for 1929–30: Allotment by University authorities, $1900.

Employees for 1929–30: Full time, 4.

Channels of Publication: Proceedings of engineering societies and the technical press.

Person to Whom Requests for Research Information Should Be Addressed: Dean of the School of Engineering.

Engineering Research Bulletins Published

1. Tangent Modulus, by O. H. Basquin. Paper No. 263, Bureau of Standards, 1924.
2. A New Method of Estimating Stream Flow, by I. A. Folse and John L. Hayford, 1929. Published by the Carnegie Institution of Washington.

Live Research Projects

1. Use of Compression Steel in Reinforced Concrete Beams. G. A. Maney and three research students.
2. Accurate Method of Measuring the Coupling Angle of a Synchronous Motor. Wm. Malcolm Bauer.
3. Efficiency of a Gas Engine as a Function of Various Gasolines. Bruce Adams, John Goergen, and advanced research students.
4. A New Fire Extinguisher to Operate at −40° F. Wm. Chas. Bauer.
5. A New Fire-Extinguishing Fluid of the Loaded Stream Type. Wm. Chas. Bauer.
6. The Effect of Shrinkage as a Controlling Factor in Increases of Compressive Reinforcing Steel Deformation with Continued Load. G. A. Maney.

INDIANA

EVANSVILLE COLLEGE, Evansville. Earl E. Harper, President.

No engineering research organization.

No engineering research reported.

UNIVERSITY OF NOTRE DAME, Notre Dame. Charles L. O'Donnell, President; Thomas A. Steiner, Acting Dean of the College of Engineering.

No engineering research organization.

No engineering research reported.

ROSE POLYTECHNIC INSTITUTE, Terra Haute. John White, Acting President.

No engineering research organization.

No engineering research reported.

TRI-STATE COLLEGE, Angola. C. C. Sherrard, President; S. S. Niehous, Dean of Engineering Department.

No engineering research organization.

No engineering research reported.

VALPARAISO UNIVERSITY, Valparaiso. William H. T. Daw, President; H. E. Bilger, Head of the Department of Engineering.

No engineering research.

IOWA

STATE UNIVERSITY OF IOWA, Iowa City. Walter A. Jessup, President; Clement C. Williams, Dean of the College of Engineering.

No engineering research organization.

No separate funds for engineering research.

Channel of Publication: Studies in Engineering, part of University Studies issued through the Graduate College.

Engineering Research Bulletin Published

No. 1. Flow of Water Through Culverts, by D. L. Varnell, F. A. Nagler, and S. M. Woodward, 1926.

Research Projects of the Past Year

1. Study of Effect of Cut-Off Channels on Des Moines River.
2. Investigation of Behavior of Scour and Other Effects on a Certain Power Dam. Laboratory study.
3. Study of Water Wheel Gates as Affecting Water Rights. Laboratory study.
4. Study of Flood Flows over Embankments. Laboratory study.
5. Comparative Studies of Devices for Carrying a Stream over a Canal. Laboratory study.
6. Study of Silt Deposition.
7. Resistance to Flow by Pile Trestles.
8. Extensive Laboratory Study of Hastings Dam Across the Mississippi in Cooperation with U. S. Army Engineers.
9. Resistance to Flow Offered by Bridge Piers.
10. Hydraulic Jump.
11. Angular Acceleration of Automobile Bodies.
12. Effects of Earth Vibrations on Masonry Structures and Foundations.

KANSAS

UNIVERSITY OF KANSAS, Lawrence. E. H. Lindley, Chancellor; George C. Shaad, Dean of the School of Engineering and Architecture, and Director of the Engineering Experiment Station.

Engineering Research Organization: Engineering Experiment Station, created by the Board of Regents, 1907.

Funds Available for 1929–30: Allotment by University authorities, $700.

Employees for 1929–30: Part time, 8, estimated equivalent to 2 full time.

Channels of Publication: Bulletins of the Engineering Experiment Station and technical periodicals.

Persons to Whom Requests for Research Information Should Be Addressed: Department concerned, School of Engineering and Architecture.

Engineering Experiment Station Bulletins Published

Bulletin No. 1, Part 1. A Ballistic Electrodynamometer Method of Measuring Hysteresis Loss in Iron, by Martin E. Rice and Burton McCollum.

Part 2. Voltage Regulations of Alternators, by Burton McCollum.

* *Bulletin No. 2.* Natural Gas: Its Properties, Its Domestic Use, and Its Measurement by Meters.

* *Bulletin No. 3.* Kansas Fuels: Coal, Oil, Gas. Part 1.—Heating Values and Proximate Analysis of Coal.

Part 2. Discussion of Sulphur Content of Bituminous Coal.

Bulletin No. 4, Part 1. The Organization and Work of the Engineering Experiment Station of the University of Kansas, by George C. Shaad.

Part 2. Vocational Education in Kansas with Courses of Study Now Offered by the University School of Engineering, by P. F. Walker.

Bulletin No. 5. Water Supplies of Kansas. Part 1.—Ground Water Supplies, by C. A. Haskins and C. C. Young.

Bulletin No. 6. Kansas Fuels: Coal, Oil, Gas. Part 1.—Heating Values and Proximate Analysis of Coal, by P. F. Walker and Walter Bohnstengel. Reprint of No. 3.

Part 2. Discussion of Sulphur Content of Bituminous Coal, by Walter Bohnstengel. Reprint of No. 3.

Part 3. Economic Effects of Washing Coal from the State Mine, by C. M. Young.

Bulletin No. 7. The Removal of Iron from Municipal Water Supplies, by James W. Schwab. (In collaboration with the Division of State Chemical Research.)

* *Bulletin No. 8.* The Measurement of Electrical Energy, Electricity Meters, Rates for Electrical Energy.

Bulletin No. 9. Sewage Disposal in Kansas. A Discussion of Practice in Certain Municipalities, Together with Instructions to Plant Operators, by F. M. Veatch, H. P. Evans, and L. E. Jackson. (In collaboration with the Division of State Chemical Research.)

Bulletin No. 10. The Present Development of Transmission Lines in Kansas, by F. Ellis Johnson.

Bulletin No. 11. A Chemical Survey of the Natural Gases of Kansas and Oklahoma, by H. C. Allen and E. E. Lyder. (In collaboration with the Division of State Chemical Research.)

Bulletin No. 12. Industrial Development of Kansas, by P. F. Walker.

Bulletin No. 13. Kansas Coal, by C. M. Young and H. C. Allen.

Bulletin No. 14. The Economic Value of Public Health Work.

Bulletin No. 15. Engineering: Its Scope, Opportunities, System of Training.

Bulletin No. 16. The Chlorination of Raw Sewerage for Odor Control.

Bulletin No. 17. Mineral Analyses of Municipal Water Supplies in Kansas, by Selma Gottlieb.

Live Research Projects

1. Strength Data of Electrical Welds in Structural Steel.
2. Loss of Head in Garden Hose.
3. Topographical Mapping from Aerial Photographs.
4. The Hydrology of Kansas.

* Out of print.

KENTUCKY

UNIVERSITY OF LOUISVILLE, Louisville. Raymond A. Kent, President; B. M. Brigman, Dean of the Speed Scientific School.

No engineering research organization. Research plans now under way. Such problems as have been undertaken have been cared for by the departments concerned.

LOUISIANA

THE TULANE UNIVERSITY OF LOUISIANA, New Orleans. Albert B. Dinwiddie, President; Douglas S. Anderson, Dean of the College of Engineering.

No engineering research organization.

No engineering research reported.

MARYLAND

THE JOHNS HOPKINS UNIVERSITY, Baltimore. Joseph S. Ames, President; John B. Whitehead, Dean of the School of Engineering.

No engineering research organization, but research work is considered a normal function of all faculties of the University. Engineering research was provided for in 1912, when the School of Engineering was founded.

Employees for 1929–30: Full time, 5; part time, 13, estimated equivalent to 7 full time.

Channels of publication: Proceedings national engineering and other scientific societies.

Person to Whom Requests for Research Information Should Be Addressed: Dean, School of Engineering.

No separate issue of engineering research bulletins.

Live Research Projects

1. Fundamental Properties of Impregnated Paper Insulation. J. B. Whitehead and W. B. Kouwenhoven. Cooperation of Utilities Research Commission.
2. Influence of Residual Air on the Life of Impregnated Paper Insulation. J. B. Whitehead. Cooperation of National Electric Light Association.
3. Fundamental Properties of Liquid Dielectrics. J. B. Whitehead. Cooperation of Engineering Foundation.
4. Life of Impregnated Paper as Related to the Impregnating Oil. F. Hamburger, Jr. Cooperation of National Electric Light Association.
5. An Investigation of the Manufacture of Water Gas with Especial Reference to the Decomposition of Steam. Lloyd Logan and W. J. Huff.
6. The Origin and Decomposition of Organic Sulfur Compounds under Gas-Making Conditions with Particular Reference to the Role of the Carbon-Sulphur Complex. J. C. Holtz and W. J. Huff.
7. The Manufacture of Gas with Special Reference to the Purification of the Gas and the Recovery of Synthetic By-Products. W. J. Huff, O. W. Lusby, and D. T. Bonney.

8. A New Method of Carrying Peak Loads in Steam Power Plants. Warren Viessman.

9. The Corrosion of Pipe by Hot Water. J. C. Smallwood.

10. The Relation of Loads to Standard Designs of Highway Bridges. J. T. Thompson. Cooperative research with the Bureau of Public Roads.

11. An Unbalanced A. C. Bridge in Magnetic Analysis. A. C. Seletzky.

12. Improvements on the Torsion Balance. J. W. Joyce.

13. Development of a Method of Measuring Distances by High Frequency Waves. E. V. Potter.

14. Harmonic Analysis of Polarized Earth Fields, Using a Cathod Ray Oscillograph. G. B. Kidd.

15. Development of a Standard of Low Power Factor for the Checking of Low Loss Measuring Devices. L. J. Berberich.

16. Electrical Properties of Chemically Pure Insulating Liquids. E. P. Barlow.

17. Effects of Electric Shock. R. L. Kelly.

MASSACHUSETTS

HARVARD UNIVERSITY, Cambridge. A. Lawrence Lowell, President; Harry E. Clifford, Dean, The Harvard Engineering School, and in charge of engineering research.

No engineering research organization, although there are various researches going on.

Funds Available for 1929–30: No general research appropriation in the Engineering School budget although the budget covered expenditures made in various researches. From time to time allotments are made for special research funds; e.g., from the Milton Fund which is a large fund for research in Harvard University; and from other organizations.

Employees for 1929–30: Full time, 3. A number of faculty members give much time to directing research. This year 23 graduate students are doing engineering research work.

Channels of Publication: Reprints are issued of reports of the work of members of the faculty as Publications from the Harvard Engineering School. This is not, in any way, a complete list of the research activities.

No complete records of engineering researches and investigations are kept on file.

Publications from the Harvard Engineering School

Requests for these reprints will be granted, so far as possible, on payment of twenty-five cents a copy.

No. 1. Piezoelectric Crystal Oscillators Applied to the Precision Measurement of the Velocity of Sound in Air and CO_2 at High Frequencies, by George W. Pierce. October, 1925.

No. 2. The Current Theories of the Hardening of Steel Thirty Years Later, by Albert Sauveur. February, 1926.

No. 3. Computation of Behavior of Electric Filters under Load, by A. E. Kennelly and Arthur Slepian. October, 1925.

* *No. 4.* Identical Electrical Networks in Series, by A. E. Kennelly. April, 1925.

* *No. 5.* The Advancement of Engineering in Relation to the Advancement of Science, by A. E. Kennelly. January, 1926.

* *No. 6.* Dendritic Segregation in Iron-Carbon Alloys, by Albert Sauveur and V. N. Krivobok. September, 1925.

* *No. 7.* The Influence of Strain and of Heat on the Hardness of Iron and Steel, by Albert Sauveur and D. C. Lee. September, 1925.

* *No. 8.* The Durometer—An Instrument for Testing Hardness, by Albert Sauveur. September, 1925.

No. 9. Le Fer "Armco," by Albert Sauveur. July, 1925.

* *No. 10.* An Investigation of the Properties of Iron-Carbon Alloys: (A) Melted in Vacuum; (B) Melted in Air; by Everett L. Reed. 1925.

No. 11. A Theoretical and Experimental Investigation of Detection for Small Signals, by E. L. Chaffee and G. H. Broning. February, 1927.

* *No. 12.* Sludge Digestion—Reaction and Control, by Gordon M. Fair and C. L. Carlson. February, 1927.

* *No. 13.* Changes During the Last Twenty Years in the World's Speed Records of Racing Animals, by A. E. Kennelly. August, 1926.

* *No. 14.* Equiangular Spiral Polygons as Presenting Themselves in Elec, trical Engineering, by A. E. Kennelly. April, 1926.

* *No. 15.* Can the Thermal Capacity of Electric Machines be Made a Simple and Practical Element of Rating?, by A. E. Kennelly. May, 1926.

* *No. 16.* Vacuum-Tube Nomenclature, by E. Leon Chaffee. March, 1927.

No. 17. Voltage Detection Coefficient, by E. Leon Chaffee. November, 1927.

* *No. 18.* Some Extensions of Theory and Measurements of Shot-Effect in Periodic Circuits, by H. B. Vincent. November, 1927.

No. 19. Studies of Sludge Digestion, by Gordon M. Fair and C. L. Carlson. Activated Sludge Digestion Characteristics. Nov., 1927. Hydrogen-Ion Control of Sludge Digestion. Dec. 1, 1927. Effect of Chlorination upon the Digestion of Sewage Solids. Dec. 29, 1927.

No. 20. The Acoustic Impedance of Straight Cylindrical Air Columns in Brass Tubes, by A. E. Kennelly and R. P. Siskind. 1927.

No. 21. The Widmanstattian Structure of Iron Alloys, by Albert Sauveur. 1927.

No. 22. Magnetostriction Oscillators. An Application of Magnetostriction to the Control of Frequency of Audio and Radio Electric Oscillations, to the Production of Sound, and to the Measurement of the Elastic Constants of Metals, by George W. Pierce. April, 1928.

No. 23. A Dynamic Study of Magnetostriction, by K. Charlton Black. April, 1928.

No. 24. Hyperbolic-Function Series of Integral Numbers and the Occasions for Their Occurrence in Electrical Engineering, by A. E. Kennelly. Aug., 1924.

No. 25. High-Voltage Measurements on Cables and Insulators, by C. L. Kasson. May, 1927.

No. 26. The Measurement of the Conductance of Electrolytes—I. An Experimental and Theoretical Study of Principles of Design of the Wheatstone Bridge for Use with Alternating Currents and an Improved Form of Direct Reading Alternating Current Bridge, by Grinnell Jones and Roswell Colt Josephs. April 5, 1928.

No. 27. A Method for Determining the Constants of an Electromagnetic Oscillograph, by A. E. Kennelly. April 21, 1928.

* Out of print.

No. 28. Normal Attenuation in Electrical Conducting Networks, by A. E. Kennelly. September, 1927.

No. 29. Gudermannian Complex Angles, by A. E. Kennelly. November, 1928.

No. 30. Historical Outline of the Electrical Units, by A. E. Kennelly. November, 1928.

No. 31. The Gamma-Alpha Transformation in Pure Iron, by Albert Sauveur and C. H. Chou. February, 1929.

No. 32. Ionization Studies in Paper-Insulated Cables—II, by C. L. Dawes, H. H. Reichard and P. H. Humphries. *Transactions* of American Institute of Electrical Engineers, 1929.

No. 33. The Condition of Self-Oscillation of a General Triode System, by Paul S. Bauer. January, 1929.

No. 34. The Application of Hyperbolic Functions to Recent Developments in Submarine Cable Telegraphy, by A. E. Kennelly. September, 1927.

No. 35. Statistical Description of the Size Properties of Non-Uniform Particulate Substances, by Theodore Hatch and Sarah P. Choate. March, 1929.

No. 36. Some Problems in Dielectric-Loss Measurements, by C. L. Dawes, P. L. Hoover, and H. H. Reichard. July, 1929.

No. 37. X-Ray Studies of Particle Size in Silica, by R. H. Aborn and R. L. Davidson. *The Journal of the Franklin Institute*, July, 1929.

No. 38. Alternating-Current Nets, by Arthur E. Kennelly. *Proceedings* of the American Academy of Arts and Sciences, September, 1929.

No. 39. Equivalent Circuits of an Electron Triode and the Equivalent Input and Output Admittances, by E. L. Chaffee. *Proceedings* of the Institute of Radio Engineers, Vol. 17, No. 9, September, 1929.

No. 40. Gudermannians and Lambertians with Their Respective Addition Theorems, by A. E. Kennelly. *Proceedings* American Philosophical Society, 1929.

No. 41. Magnetic Circuit Units, by A. E. Kennelly. *Winter Convention Proceedings* of the American Institute of Electrical Engineers, January, 1930.

No. 42. A Thermodynamic Analysis of the Steady Flow of Fluids, by C. Harold Berry. *Mechanical Engineering*, November, 1929.

No. 43. Ionization Studies in Paper-Insulated Cables—III, by C. L. Dawes and P. H. Humphries. *Winter Convention Proceedings* of the American Institute of Electrical Engineers, January, 1930.

No. 44. Influence of Rate of Cooling on Dendritic Structure and Microstructure of Some Hypoeutectoid Steel, by Albert Sauveur and C. H. Chou. *Proceedings* of the American Institute of Mining and Metallurgical Engineers, February, 1930.

No. 45. Austenite and Its Decomposition, by Albert Sauveur. *Transactions* of the American Society for Steel Treating, February, 1930.

No. 46. Steel at Elevated Temperatures, by Albert Sauveur. *Transactions* of the American Society for Steel Treating, March, 1930.

No. 47. Studies of Sludge Digestion, by Gordon M. Fair, M. C. Whipple, Louis Klein, and E. W. Moore.

1. Effect of Pressure upon Sludge Digestion. Reprinted from *Industrial and Engineering Chemistry*, Vol. 21, March, 1929.

2. The Effect of Age of Sewage Solids upon Their Digestibility. Reprinted from *Sewage Works Journal*, Vol. I, No. 1, October, 1928.

3. Observations on the Reliability of Different Methods for Determining the pH of Sewage Sludge. Reprinted from *Sewage Works Journal*, Vol. II, No. 1, January, 1930.

No. 48. Measurement of the Dielectric Constant and Index of Refraction of Water and Aqueous Solutions of KCl at High Frequencies, by F. H. Drake, G. W. Pierce, and M. T. Dow. *Physical Review*, March, 1930.

No. 49. Measurements of the Dielectric Constants of Conducting Media, by Jeffries Wyman, Jr. *Physical Review*, March, 1930.

Research Activities

Important investigations begun, continued, or completed during the year:

R. H. Aborn:

1. The Design of Improved Cameras for X-Ray Diffraction Investigations.
2. Structure Studies on a Borate Mineral and Gold Telluride.
3. The Occurrence of Oxygen in Iron and Steel and Its Influence on Hot Brittleness.
4. X-Ray Investigation of the Stability of Austenitic Steels at Low and High Temperatures.
5. Metallographic Investigation of Rail Failures.
6. X-Ray Criteria for Optimum Annealing of Metal Castings and Forgings.

C. A. Adams:

The Welding of Rail Joints, the Welding of Pressure Vessels, and Seven Projects Dealing with Fundamentals of Welding Being Carried on in the Universities of the Country, under the American Bureau of Welding.

C. H. Berry:

Investigation of Problems in Handling and Burning Coal, for a Large Industrial Corporation.

E. L. Chaffee:

1. The Electrical Response from Various Positions on the Retina of Frog and Horned Toad.
2. Temperature Coefficient of Electrical Response of the Retina.
3. Operating Characteristics of Triode Oscillators.
4. Theory of Non-Linear Electrical Circuits with Special Reference to Detection with Large Signal Voltages.
5. Production of Very Short Waves.
6. Velocity of Electrons by Absolute Method.
7. Ionization and Resonance Potential by Dynamic Method.

H. E. Clifford:

Losses in Dielectrics at High Frequencies.

C. L. Dawes:

1. Study and Design of Demagnetizers for Use in Connection with Magnetic Chucks and Lifting Magnets.
2. Ionization Studies in Paper-Insulated Cables.
3. Electrical Characteristics of Ionized Gas Films.

G. M. Fair:

1. Thermophilic Sludge Digestion.
2. Measurement of the Hydrogen Ion Concentration of Sewage Sludges.
3. Expansion of Sand in Rapid Sand Filters.
4. Hydraulic Characteristics of Corroding Water Pipes.

L. C. Graton:

1. Origin of the Gold of the Rand: *Part 1*, Testimony of the Conglomerates.
2. Influence of Rock Permeability on Ore Deposition.
3. The Morro Velho Gold Deposit, Brazil.
4. Persistence of Ore at Depth.
5. Mining at Depth.

T. F. Hatch:

1. The Dust Hazard in the Granite-Cutting Industry and Methods of Control.

2. Polarization of the Tyndall Beam in Relation to Particle Size of Non-Uniform Particulate Substances.

3. A Study of the First Fundamental Laws Governing the Flow of Air into Dust Exhaust Hoods.

L. J. Johnson:

Problems in the Design of Large, Vertical-Sided Astronomical Observatory Domes of Steel.

Grinnell Jones:

1. Measurements of the Transference Numbers of Lithium Chloride.
2. Study of the Normal Potential of the Bromium Electrode.
3. The Measurements of the Conductance of Electrolytes.

L. S. Marks:

Reaction Gas Turbine.

D. H. McLaughlin:

1. Reports on Various Mining Properties in Ontario, Quebec, South Dakota, New Mexico, California, Nevada, and Durango (Mexico).

2. Geological Work on Pre-Cambrian Rocks of the Black Hills of South Dakota.

3. Geological Work on the Gold Ores of the Homestake Mine, Lead, S. D. (in Capacity of the Consulting Geologist of the Homestake Mining Co.).

4. Geological Work at the Properties of the San Luis Mining Co. at Tayoltita, Durango, Mexico, for the Company.

A. E. Norton:

1. Lubrication of Air Compressors.
2. Improvements in Automobile Brakes.

G. W. Pierce:

1. Magnetostriction Devices for Controlling Frequency.

2. Magnetostriction Oscillators for Velocity of Sounds, Velocity of Electric Waves, Standards of Frequency.

Albert Sauveur:

1. Enameling of Iron and Steel.
2. Influence of Elements on the Eutectoid Point of Steel.
3. Influence of Calcium on Iron and Steel.
4. Influence of Oxygen on Iron and Steel.
5. Ageing of Iron and Steel.
6. Steel at Elevated Temperatures.
7. Induction Annealing.
8. Rolling with and without Tension.

A. E. Wells:

1. The Use of Diphenyl as a Heat Exchange Medium in Chemical and Metallurgical Operations Involving the Heating of Fluids to Temperatures up to 750° F.

2. Influence of Gases on Casting Refined Copper.

3. Factors Affecting the Separation of Lead and Zinc Sulphides from Complex Lead-Zinc Ores.

M. C. Whipple:

Corrosion of Copper, Brass, and Iron Water Pipes.

LOWELL TEXTILE INSTITUTE, Lowell. Charles H. Eames, President; Herbert J. Ball, Professor of Textile Engineering.

No engineering research organization.

No separate funds for engineering research.

Channel of Publication: Bulletin of the Lowell Textile Institute.

Research Bulletins Published

There is no charge for any of these bulletins.

Bulletin No. 1. An Investigation Showing the Effect of Twist upon the Strength and Elasticity of a Cotton Yarn, by Charles H. Forsaith. Series 23, No. 4. May, 1920.

Bulletin No. 2. An Investigation Showing the Relation of Single and Ply Twist to the Strength of a Two-Ply Yarn. Thesis by W. C. Chang. Series 24, No. 4. May, 1921.

Bulletin No. 3. The Textile Industry as a Vocation, by George H. Johnson. Series 25, No. 2. November, 1921.

Bulletin No. 4. An Investigation Showing the Relation of Single and Ply Twist to the Strength of a Two-Ply Yarn. Theses by Harold B. Hodge and Stanley Gillie. Series 25, No. 4. May, 1922.

Bulletin No. 5. A Comparative Study of the Properties of Yarns of Equivalent Count. Series 26, No. 4. May, 1923.

Bulletin No. 6. Some Experiments in the Use of Long Drafts in Spinning. Theses by J. A. Miller and S. F. Toupin. Series 27, No. 4. May, 1924.

Bulletin No. 7. The Effect of Regain upon the Strength and Elasticity of a Worsted Yarn. Thesis by Philip R. Lowe. Series 28, No. 2. November, 1924.

Bulletin No. 8. Study of Relation of Yarn Strength to Fiber Strength in a 23-5-3 Cord. Studies by Leonard Wilcox and Clarence Anderson. Series 28, No. 4. May, 1925.

Bulletin No. 9. Study of Relation of Twist to Contraction in a Single Cotton Yarn. Series 29, No. 2. November, 1925.

Bulletin No. 10. A Tentative Strength Standard for Two-Ply Cotton Yarns. Thesis by Francis C. Kennedy. Series 30, No. 4. May, 1927.

Bulletin No. 11. The Textile Engineer—His Training and Opportunities, by Herbert J. Ball. Series 31, No. 4. May, 1928.

Bulletin No. 12. A Study of the Tension in Yarns during Spinning, by Herbert J. Ball. Series 32, No. 4. May, 1929.

Bulletin No. 13. Long Draft vs. Normal Draft, by Gilbert R. Merrill. Series 33, No. 2. November, 1929.

Live Research Projects

1. A Study of the Possibility of Using Oscillatory Circuits for Measuring the Evenness of Textile Materials.
2. The Effect of Twist upon the Physical Properties of Rayon Yarns.
3. The Development of an Instrument for Measuring Lustre and a Study of the Finish of Cotton Fabrics by Means of It.
4. A Determination of the Relation between Yarn Strength and Fabric Strength.
5. A Study of the Effect of Twist upon the Strength and the Elasticity of a Cotton Yarn.
6. A Determination of the Relation between the Strength and Regain of Worsted Fabrics.
7. The Development of an Automatic Device for Measuring and Recording the Tension in Yarns during Spinning.
8. A Determination of the Relation between the Strength and Regain of Worsted Yarns.

These projects have been in progress from two to four years as thesis work under the direction of Herbert J. Ball.

NORTHEASTERN UNIVERSITY, Boston. Frank Palmer Speare, President; Carl Stephens Ell, Vice-President and Dean.

No engineering research organization. Such investigations of a technical nature as are carried on are in the nature of thesis work by candidates for the Bachelor's degree.

No engineering research projects or bulletins reported.

TUFTS COLLEGE, Tufts College. John A. Cousens, President; George P. Bacon, Dean of the Engineering School.

Engineering Research Organization: Research conducted by heads of departments; not fully organized at present.

Funds Available for 1929–1930: Allotments by College authorities, $5,000 approximately; grants from other sources, $1,000 approximately.

Channels of Publication: Proceedings of engineering societies.

Live Research Projects

Studies of Radio Transmission Phenomena Including:

1. Measurement of Field Strength from Low, Intermediate and High Frequency Stations. P. A. deMars and G. W. Kenrick.
2. Measurements of Height of the Kennelly Heaviside Layer by the Pulser Method. P. A. deMars and G. W. Kenrick.

WORCESTER POLYTECHNIC INSTITUTE, Worcester. Ralph Earle, President; F. W. Roys, Chairman, Committee on Industrial Research.

Engineering Research Organization: Committee on Industrial Research, created by the Board of Trustees, 1926.

Funds Available for 1929–1930: Allen Hydraulic Research Fund.

Employees for 1929–1930: Part time, 4.

Channels of Publication: Professional engineering press.

No engineering research projects reported.

MICHIGAN

UNIVERSITY OF DETROIT, Detroit. John P. Morrissey, Regent; Russell E. Lawrence, Dean of Engineering.

No engineering research organization. While considerable testing and investigation is done for inventors and manufacturers, most of it is confidential and not for publication. The University is contemplating the organization of a Research Department, which should be in operation by September, 1930.

MICHIGAN COLLEGE OF MINING AND TECHNOLOGY, Houghton. W. O. Hotchkiss, President.

Engineering Research Organization: Committee, composed of heads of departments, created by the Legislature, 1927.

Funds Available for 1929–1930: Direct appropriation by legislature, $50,000.

Employees for 1929–1930: Full time, 6; part time, 38, estimated equivalent to 13 full time.

Channels of Publication: Proceedings of engineering societies, the technical press, and the Bulletin of the Michigan College of Mining and Technology.

Engineering Research Bulletins Published

1. Recent Developments in Methods of Mining in Michigan Iron Mines, and Timbering Practice in Michigan Iron Mines, by Roland D. Parks. 1929. Vol. 2, No. 3, Bulletin of the Mich. Coll. of Min. and Tech.
2. Scraping Practice in Michigan Iron Mines, by Robert C. Matson. 1929. Vol. 2, No. 4, Bulletin of the Mich. Coll. of Min. and Tech.
3. Color and Lustre as a Basis for Mechanical Separation, by A. T. Sweet. 1928. Lake Superior Mining Institute.
4. Photo-electro Metallurgy, by R. W. Drier. 1930. Reprint from *Industrial Chemistry*, also Vol. 3, No. 3, Bulletin of the Mich. Coll. of Min. and Tech.
5. The Correlation of the Ultimate Structure of Hard Drawn Copper Wire with Its Electrical Conductivity, by C. T. Eddy and R. W. Drier. 1929. A. I. M. & M. E.
6. Two-Ton Experimental Reverberatory Furnace at the Michigan College of Mining and Technology, by C. T. Eddy. 1929. Lake Superior Mining Institute.
7. The X-Ray Laboratory at the Michigan College of Mining and Technology, by R. W. Drier. 1929. Lake Superior Mining Institute.
8. An Outline of Flotation, by N. H. Manderfield. 1928. Lake Superior Mining Institute.
9. Flotation Testing Equipment at the Michigan College of Mines, by N. H. Manderfield. 1930. Lake Superior Mining Institute.
10. Manganese, by A. T. Sweet.

Live Research Projects

1. Application of Electrical Equipment to Mining. S. Toyrshow and G. W. Swenson.
2. Investigation of Radio Field Strengths Above and Below Earth's Surface in Copper Country of Michigan. G. W. Swenson.
3. Bottom Topography of Lake Superior.
4. Physical Geography of Keweenaw Peninsula.
5. Sensitivity of the Dip Needle. C. O. Swanson. In press.
6. The Clarksburg Ophites. Forrest Leedy.
7. The Stratigraphy of the Negannee Formation of the Marquette District. J. L. Adler and A. N. MacIntosh.
8. Method of Preparing and Testing Mine Drill Steel. Donald C. Palmer and R. R. Seeber.
9. Elementary Text on Mining. C. H. Baxter, R. C. Matson, and R. D. Parks.
10. Text on Methods of Mining. C. H. Baxter and R. D. Parks.

11. Measurements of Electrical Resistivity of Minerals and Rocks.
12. Measurements of Electrical Resistivity of Large Masses of Earth and Rock in Place with a View to Determination of Geologic Substructure.
13. Measurements of Wave Transmission in Soils and Rocks. Geophone Methods.
14. Dip Needle and Magnetometer Surveys.
15. Measurements of Magnetic Permeability of Rocks at Field Strengths Comparable with Earth's Field.

UNIVERSITY OF MICHIGAN, Ann Arbor. Alexander Grant Ruthven, President; Herbert Charles Sadler, Dean of the Colleges of Engineering and Architecture; Albert Easton White, Director of the Department of Engineering Research.

Engineering Research Organization: Department of Engineering Research, created by the Board of Regents, October, 1920.

Funds Available for 1929–1930: Allotment by University authorities, $26,500; cost of investigations paid for by industries concerned, about $350,000 for last year.

Employees for 1929–30: About 35 employed on research.

Channels of Publication: Department of Engineering Research Bulletins, Reprints and Circulars.

Department of Engineering Research Publications

* *Bulletin No. 1.* Investigation of Charcoal and Coke Pig Irons, by W. E. Jominy. 27 pages. January, 1926.

Bulletin No. 2. Volume Changes in Gypsum Structures Due to Atmospheric Humidity, by A. H. White. 26 pages. February, 1926. Fifty cents.

Bulletin No. 3. The Neutral Zone in Ventilation, by J. E. Emswiler and W. C. Randall. 26 pages. April, 1926. Fifty cents.

Bulletin No. 4. Stainless Steel, a Digest with Abstracts and Bibliography, by Albert E. White and Claude L. Clark. 82 pages. November, 1926. Fifty cents.

Bulletin No. 5. The Elements of Metal Cutting, by Orlan W. Boston. 95 pages. December, 1926. One dollar.

Bulletin No. 6. A Method for Predicting Daylight from Windows, by H. H. Higbie and W. C. Randall. 76 pages. January, 1927. Fifty cents.

Bulletin No. 7. The Relation of Motor Fuel Characteristics to Engine Performance, by G. G. Brown. 129 pages. May 1, 1927. One dollar.

Bulletin No. 8. A Study of Patents Dealing with the Electrodeposition of Chromium, by Richard Schneidewind. 49 pages. April, 1928. Fifty cents.

Bulletin No. 9. A Manual of Flight Test Procedure, by W. F. Gerhardt. Revised by L. V. Kerber. 122 pages. December, 1927. One dollar.

Bulletin No. 10. A Study of Chromium Plating, by Richard Schneidewind. 140 pages. September, 1928. One dollar.

Bulletin No. 11. The Stability of Metals at Elevated Temperatures, by Albert E. White and Claude L. Clark. 130 pages. November, 1928. One dollar.

Bulletin No. 12. Application of Trigonometric Series to Cable Stress Analysis in Suspension Bridges, by George C. Priester. 50 pages. March, 1929. One dollar.

* Out of print.

Bulletin No. 13. A Practical Method for the Selection of Foundations Based on Fundamental Research in Soil Mechanics, by W. S. Housel. 117 pages. October, 1929. One dollar.

Circular No. 1. A Proposed Standard Procedure for Computing Flight-Test Climb Data, by L. V. Kerber. 6 pages. May, 1927. Twenty-five cents.

Circular No. 2. A Vapor-Pressure Chart for Hydrocarbons, by Hal B. Coats and George Granger Brown. 17 pages. December, 1928. One dollar.

Circular No. 3. Commercial Chromium Plating, by Richard Schneidewind. 60 pages. January, 1930. Fifty cents.

Reprint No. 1. Zeolite Water Treatment in a Large Central Heating Plant, by Alfred H. White, J. H. Walker, Everett P. Partridge, and Leo F. Collins. 27 pages. July, 1927. Fifty cents.

Reprint No. 2. Machinability of Metals, by Orlan W. Boston. 47 pages. February, 1928. Fifty cents.

Reprint No. 3. Properties of Ferrous Metals at Elevated Temperatures, by A. E. White and C. L. Clark. 16 pages. February, 1928. Fifty cents.

* *Reprint No. 4.* A Study of Centrifugally-Cast Pipe (Metal-Mould Process) Versus Sand-Cast Pipe, by F. N. Menefee and A. E. White. 37 pages. August, 1928.

Reprint No. 5. Baking Practice for Oil-Sand Cores, by H. L. Campbell. 5 pages. August, 1929. Twenty-five cents.

Live Research Projects

About 50 projects under investigation at the present time. Subjects not reported.

Completed or Discontinued Engineering Research Projects

The following is a partial list representing various types of researches selected from a total of about 700 since 1921.

1. Scientific methods of obtaining uniform illumination from daylight.
2. Study of self-lubricating bushings.
3. Investigation of single phase motors for the purpose of bringing about further improvements.
4. Scientific methods for obtaining the maximum of natural ventilation.
5. Scientific investigation dealing with the art of cutting metals.
6. Investigation of the special characteristics of charcoal iron.
7. The development of a method for measuring accurately the noise in roller bearings and gears.
8. Investigation of the characteristics of core oils and core binders.
9. Investigation of corrosion in heating systems.
10. Study of motor fuels.
11. Investigation of the causes leading to the discoloration of copper sheets.
12. Development of a machine for measuring the depth of case by magnetic methods.
13. Investigation of paints and varnishes.
14. Investigation of clay for brick manufacture.
15. Investigation of the character of tin plate for canning purposes.
16. Investigation of the characteristics of gypsum as a building material.
17. Fundamental investigation of plating, particularly nickel and chromium.
18. Investigation of stainless steel.
19. Investigation of refrigerating media.
20. Investigation of the disposal of waste in paper manufacturing.
21. Investigation of oxychloride cements for water proofing.

* Out of print.

22. Fundamental study of ignition phenomena.
23. Fundamental study of the characteristics of metals at elevated temperatures.
24. Investigation of strain measurement in a large steel-frame building.
25. Study of the properties of natural gasoline.
26. Study of antifreeze compounds.
27. Study of the insulating characteristics of celotex, balsam wool, masonite, and other products.
28. Study of transmission problems.
29. Investigation of the cause of failure of turbine blades.
30. The characteristics of lead at elevated temperatures.
31. The metallurgical factors in the forging of steel.
32. The influence of time, rate of flow, and composition of gases on the scaling of steel.
33. Investigation of the stresses in aerial line structures.
34. Boiler feed water studies.
35. Study of problems relating to the manufacture of artificial gas.
36. The adhesion tension of liquids against solids as applied to the study of pigments.
37. Investigation of the crystallization characteristics of various chemical compounds.
38. Effect of products of combustion on the shrinkage of metal in brass melting by city gas.
39. Permeability to various gases of various types of alloy retorts.
40. Investigation as to the economical and practicable methods for eliminating moisture from city gas.
41. Fundamental investigation of the bearing power of soils.
42. Investigation of the candle power and current consumption of various types of bulbs.
43. Study of the decarburization of steel in different types of furnace atmospheres.
44. Investigation and study of shock absorbers.
45. Investigation of water pumps.
46. The characteristics of non-shatterable laminated glass.
47. Fundamental study for the purpose of further improving the quality of steel.
48. Investigation of compressor valve materials.
49. Fundamental study of radio tubes.
50. Investigation of characteristics of springs and spring materials.
51. Investigation of a method to obtain maximum allowable heat transfer in the heating of asphalt with city gas.
52. Investigation in television.
53. Investigation as to the application of the solution cycle in steam generation.
54. Investigation relative to the transmission of light through glass.
55. Investigation of petroleum products.

MISSISSIPPI

UNIVERSITY OF MISSISSIPPI, University. Alfred Hume, Chancellor.

No engineering research organization.

No engineering research at present.

MISSOURI

WASHINGTON UNIVERSITY, St. Louis. George P. Throop, Chancellor; A. S. Langsdorf, Dean of the Schools of Engineering and Architecture, and Director of the Department of Industrial Engineering and Research.

Engineering Research Organization: Department of Industrial Engineering and Research, created by the Board of Directors, June, 1926.

Funds Available for 1929–1930: Grants from outside sources, $2,750.

Employees for 1929–1930: Part time, 3, estimated equivalent to 2 full time.

Channels of Publication: Washington University Studies, and Proceedings or Transactions of National engineering societies.

Washington University Studies—Scientific Series

Vol. 1, Pt. 1, No. 1. Graphical Determination of Flux Density in Armature Teeth, by A. S. Langsdorf.

Graphical Determination of the Characteristics of Direct Current Generators and Motors, by A. S. Langsdorf.

The Effect of Moving Loads on Steel Railroad Bridges, by E. O. Sweetser. July, 1913.

Vol. 1, Pt. 1, No. 2. The Measurement of High Voltages, by W. B. Kouwenhaven.

Phase Relations in Interlinked Polyphase Circuits, by A. S. Langsdorf. Jan., 1914.

Vol. 2, Pt. 1, No. 1. Operating Characteristics of a Self-Regulating Automobile Lighting Generator, by A. S. Langsdorf.

The Preparation and Properties of Neutral Ammonium Salts of Organic Acids, by L. McMaster. July, 1914.

Vol. 4, Pt. 1, No. 2. The Neutral Ammonium Salts of Some Substituted Benzoic Acids, by L. McMaster and J. H. Godlove.

Acidimetric Standardization of Iodimetric Solutions, by L. F. Nickell and J. H. Oetting. Jan., 1917.

Vol. 5, Pt. 1, No. 1. Soot Fall Studies in St. Louis, by E. L. Ohle and L. McMaster.

The Operation of the Non-Synchronous Rotary Spark Gap, by A. S. Blatterman.

Investigation of Hydrocarbon Oil from High Pressure Gas Mains, by L. McMaster, J. C. Walker, and E. F. Werner. July, 1917.

Vol. 5, Pt. 1, No. 2. The Nitriles of Fumaric and Maleic Acids, by L. McMaster and F. B. Langreck.

The Diamidoxime of Fumaric Acid, by L. McMaster and F. B. Langreck. Jan., 1918.

Vol. 6, Pt. 1, No. 1. Empirical Equations of the Speed and Torque Characteristics of the Series Motor, by A. S. Langsdorf. July, 1918.

Vol. 7, Pt. 1, No. 1. The Determination of Acetic Acid in White Lead, by L. McMaster and A. E. Goldstein. July, 1919.

Vol. 7, Pt. 1, No. 2. Notes on the Geometry of the Characteristic Curves of the Synchronous Motor, by A. S. Langsdorf. Jan., 1920.

Vol. 10, Pt. 1, No. 2. Electric Wave Filters, by R. S. Glasgow.

Effectiveness of Artificial Illumination at Twilight, by H. G. Hake. Jan., 1923.

Vol. 11, No. 1. A Method for Determining the Pitch of Sound, by F. W. Schramm.

The Extraction of Tannin from Tea, by L. McMaster and Edison H. Smith.

The Preparation and Properties of Some Sulfonamides of Paraxylene, by L. McMaster and E. H. Smith. July, 1923.

Vol. 12, No. 1. A More Exact and Rational Analysis for Modern Clutch Design, by F. A. Berger. July, 1924.

Vol. 13, No. 2. A New Method of Suppressing Oscillations in Tuned Radio Frequency Circuits, by R. S. Glasgow. Jan., 1926.

No. 1. Mean Velocity of Flow of Water in Open Channels, by H. R. Grummann. Oct., 1928.

No. 3. Oscillations of Compound Springs, by A. S. Langsdorf. Oct., 1929.

Live Research Projects

1. Fatigue of Timber.
2. Electrodeposition of Alloys.
3. Quantitative Measurement of Atmospheric Smoke Pollution.
4. Measurement of Atmospheric Dust.
5. Factors in Garage Ventilation.
6. Danger of Fire Due to Overheated Warm Air Ducts.
7. Pole Face Losses in Electrical Machinery.

MONTANA

MONTANA SCHOOL OF MINES, Butte. Francis A. Thomson, President and Director State Bureau of Mines and Geology.

Engineering Research Organization: State Bureau of Mines and Geology, created by the legislature, 1919.

Funds Available for 1929–1930: Direct appropriation by legislature, $5,000; allotment by School authorities, $8,000.

Employees for 1929–1930: Full time, 5; part time, 7, estimated equivalent to 2½ full time.

Channels of Publication: Bulletins and the technical press.

State Bureau of Mines and Geology Bulletins Published

Bulletin No. 1. The Montana State Bureau of Mines and Metallurgy. (An explanation of its purpose and operation.) 1919.

Bulletin No. 2. Directory of Montana Metal and Coal Mines. 1919.

Bulletin No. 3. Mechanical Ore Sampling in Montana, by H. B. Pulsifer. 1920.

* *Bulletin No. 4.* Geology and Oil and Gas Prospects of Central and Eastern Montana (with geologic map), by C. H. Clapp, Arthur Bevan, and G. S. Lambert. 1921. Price $1.00.

* *Bulletin No. 5.* The Location, Representation, and Patenting of Mineral Lands in Montana, by A. E. Adami. 1923.

Memoir No. 1. The Kevin-Sunburst and Other Oil and Gas Fields of the Sweetgrass Arch, by Eugene S. Perry. 1929.

* Out of print.

Live Research Projects

A. GEOLOGY

A1. Geology and Ore Deposits of the Argenta and Bannack Mining Districts, Beaverhead County. P. J. Shenon.

A2. Ground Water of Eastern and Central Montana. Eugene S. Perry.

A3. Correlations and Mapping of Belt Rocks in Western and Northwestern Montana. Charles H. Clapp.

A4. Geology of the Flathead (Hog Heaven) Mining District, Lake County. P. J. Shenon and A. V. Taylor.

A5. Geology along the Yellowstone Trail across Montana (1928–29–30). Eugene S. Perry.

A6. Geologic Map of Montana (in Cooperation with U. S. Geological Survey).

B. METALLURGY

B1. The Study of the Hard and Soft States of Metals and Alloys. Curtis L. Wilson and Earl Lindlief.

B2. The Constitution and Structure of the Ternary Mattes Cu_2S-PbS-Sb_2S_3, with Especial Reference to Specific Gravity. Curtis L. Wilson and Herbert Hard.

B3. The Electrical Conductivity of Cold-Drawn and Annealed Metals and Alloys. Curtis L. Wilson, C. Becker Hoskins and Noah Gershevsky.

B4. The Effect of Impurities upon the Current Efficiency in the Production of Electrolytic Zinc. Curtis L. Wilson, Louis Nuckols, and Joseph Newton.

B5. The Effect of Various Methods of Pouring upon the Formation of Pipe in Ingots. Curtis L. Wilson and Herbert Hard.

B6. The Relation between Brinell, Rockwell, Scleroscope, and Scratch Hardnesses of Certain Minerals. Curtis L. Wilson and Herbert Hard.

C. ORE DRESSING

C1. The Effect of Grain Size on Flotation, as Revealed by a Study of Synthetic Ores. A. M. Gaudin and John O. Groh.

C2. The Effect of Grain Size on Flotation, as Revealed by a Study of Mill Products. A. M. Gaudin and H. B. Henderson.

C3. The Selective Flotation of Lead-Copper Ores. Guy E. Sheridan.

C4. The Selective Flotation of Galena from Chalcocite. A. M. Gaudin and T. DeVries.

C5. The Selective Flotation of Copper-Zinc Ores. A. M. Gaudin and Gailen T. Vandel.

D. PETROLEUM TECHNOLOGY

D1. The Effect of Ultra-Violet Rays on the Distillation of Oil Shale. Will V. Norris.

NEW HAMPSHIRE

DARTMOUTH COLLEGE, Hanover. Ernest Martin Hopkins, President; Raymond Robb Marsden, Dean of the Thayer School of Civil Engineering.

No engineering research organization.

No engineering research at present.

NEW JERSEY

NEWARK COLLEGE OF ENGINEERING, Newark. Allen R. Cullimore, Director.

No engineering research organization.

No engineering research reported.

PRINCETON UNIVERSITY, Princeton. John Grier Hibben, President; Arthur M. Greene, Jr., Dean of the School of Engineering.

No engineering research organization. Research is being done continuously, by graduate students under the direction of the various professors.

Funds Available for 1929–1930: Allotment by University authorities as part of regular budget of the School of Engineering, $500.

Employees for 1929–1930: Part time, 4, estimated equivalent to 1 full time.

Channels of Publication: Proceedings of the engineering societies.

Live Research Projects

1. Investigation of Zeppelin Cell.
2. Investigation of Stresses in Suspension Bridge Model.
3. Investigation with Thirolon Tubes.
4. Investigation on Supercharge with Gasoline Engine.

Discontinued or Completed Engineering Research Projects

which resulted in valuable data not published in bulletins or circulars, but available

1. Investigation of Arch Dam.
2. Investigation of Steam Cooling of Gas Engine.
3. Investigation of Skew Arch with Rubber Model.

STEVENS INSTITUTE OF TECHNOLOGY, Hoboken. Harvey N. Davis, President; Franklin DeRonde Furman, Dean; Joseph H. Keenan, Chairman of the Committee on Research and Industrial Contacts.

Engineering Research Organization: Committee on Research and Industrial Contacts, created by the faculty, 1929.

Most of the members of the faculty do research work directly for the industries. Some of this is of very high grade. Usually, however, these projects do not result in publication. No men are engaged full time on engineering research, but any member of the instruction staff who wishes to undertake fundamental research can find some time for it.

By action of the faculty a research fund has been established which is supported entirely by members of the faculty from additional charges to clients in industrial contact work. During the past year this fund amounted to about $900.

Channels of Publication: Proceedings and bulletins of national engineering societies.

Live Research Projects

1. Photomicrophotography, Particularly of Metals. Percy Hodge.
2. Research on Properties of Steam. Harvey N. Davis and J. H. Keenan.
3. Identification of Fire-Arms from Markings on Projectiles. C. O. Gunther.

Discontinued or Completed Engineering Research Projects

which resulted in valuable data not published in bulletins or circulars, but available

Audion Circuits. Institution of Radio Engineers *Transactions*, Vol. 6, pp. 63–95.

NEW MEXICO

NEW MEXICO SCHOOL OF MINES, Socorro. E. H. Wells, President and Director of the State Bureau of Mines and Mineral Resources.

Engineering Research Organization: State Bureau of Mines and Mineral Resources, created by the legislature, 1927.

Funds Available for 1929–1930: Direct appropriation by legislature, $15,000.

Employees for 1929–1930: Full time, 1; part time, 3, estimated equivalent to 1 full time.

Channels of Publication: Bulletins and Circulars of the State Bureau of Mines and Mineral Resources.

State Bureau of Mines and Mineral Resources Bulletins Published

* *Bulletin No. 1.* The Mineral Resources of New Mexico, by Fayette A. Jones. 1915.

* *Bulletin No. 2.* Manganese in New Mexico, by E. H. Wells. 1918.

* *Bulletin No. 3.* Oil and Gas Possibilities of the Puertecito District, Socorro and Valencia Counties, New Mexico, by E. H. Wells. 1919.

Bulletin No. 4. Fluorspar in New Mexico, by William Drumm Johnston, Jr. 1928. Sixty cents.

Live Research Projects

1. The Ore Deposits of Socorro County, New Mexico, with Special Attention to the Magdalena District. In cooperation with the U. S. Geological Survey.
2. Bibliography of New Mexico Geology and Mining.
3. Mining and Mineral Laws of New Mexico.
4. Mineral Resources of New Mexico and Their Economic Features.

THE UNIVERSITY OF NEW MEXICO, Albuquerque. J. F. Timmerman, President; R. S. Rockwood, Dean of the College of Engineering.

No engineering research organization.

* Out of print.

Each head of a department directs the research work of his own department with the approval of the dean.

Channels of Publication: Engineering Society Journals. University bulletins will probably be issued to cover engineering research, until the establishment of an Engineering Experiment Station issuing its own bulletins.

Live Research Projects

1. Evaporation Data for Irrigation. A. Diefendorf.
2. Corona Losses at High Altitudes. University of New Mexico Branch of the A. I. E. E.
3. The Action of Electrical Condensers. F. M. Denton.

Published Research

1. The Graphical Solution of A. C. Transmission Line Problems, by F. M. Denton. *Journal of the American Institute of Electrical Engineers*, 1929.
2. Methods of Measuring Corona Losses in Transmission Lines. Read by the Senior Class in Electrical Engineering of the University of New Mexico at the March, 1930, Convention of the A. I. E. E. held at Columbia, Missouri.

NEW YORK

ALFRED UNIVERSITY, Alfred. B. C. Davis, President; C. F. Binns, Director of the New York State School of Clayworking and Ceramics; Charles R. Amberg, in charge of engineering research.

What engineering research is done is through individual initiative. It is published where the author sees fit.

CLARKSON COLLEGE OF TECHNOLOGY, Potsdam. Joseph Eugene Rowe, President; Frederick C. Wilson, Dean of Engineering.

No engineering research organization.

No engineering research at present.

COLLEGE OF THE CITY OF NEW YORK, New York. Frederick B. Robinson, President; Frederick Skene, Dean of the School of Technology.

No engineering research organization.

No engineering research reported.

COLUMBIA UNIVERSITY, New York. Nicholas Murray Butler, President; Joseph W. Barker, Dean of the Faculty of Engineering.

No engineering research organization, but research is done in the engineering departments.

Channels of Publication: Technical and scientific journals.

COOPER UNION, New York. R. Fulton Cutting, President; F. M. Hartman, Dean.

No engineering research organization.

No engineering research reported.

MANHATTAN COLLEGE, New York. Brother Cornelius, President; Brother Amandus Leo, Dean.

No engineering research organization.

No engineering research reported.

NEW YORK UNIVERSITY, New York. Elmer Ellsworth Brown, Chancellor; Collins P. Bliss, Dean of the College of Engineering.

No engineering research organization. Work of this kind is done by individuals in cooperation with the industries. The results are seldom published.

POLYTECHNIC INSTITUTE OF BROOKLYN, P. R. Kolbe, President; E. J. Streubel, Dean.

No engineering research organization. Research largely individual.

Employees for 1929–1930: Full time, 1; part time, 6, estimated equivalent to 2 full time.

Channels of Publication: Society Bulletins.

Live Research Project

Shellac Research. Fellowship privately financed.

RENSSELAER POLYTECHNIC INSTITUTE, Troy. Palmer C. Ricketts, Director.

No general engineering research organization. Each department head is in charge of the research in his department.

The funds for research are furnished upon application by the various departments. The allotment varies, possibly $4,000 or $5,000 a year.

Research is done by heads of departments, instructors, and graduate and undergraduate students.

Channels of Publication: Engineering and Science Series, and various technical publications.

Engineering and Science Series Bulletins Published *

No. 1. Metallic Titanium, by Matthew A. Hunter. 1911.

No. 17. An Optical Method of Determining Internal Stresses in Homogeneous Materials, by Charles F. Ffolliott.

The Measurement of Intensive Magnetic Fields by Means of the Zeeman Effect on the Zinc Triplet, by Walter C. Michaels. 1927.

No. 18. The Strength of Flat Plates, by Tandy A. Bryson.

The Strength of Flat Plates, by Thomas Cheeger.

The Stresses in Flat Plates, by Harvard H. Gorrie. 1928.

No. 19. The Fair Price to Pay for Electrical Energy, by William Lispenard Robb. 1928.

* List of bulletins not reported. Titles given are from bulletins in files of the editor.

No. 20. A Study of the Production of Chromium Surfaces for Retarding the Corrosion of Nickel at High Temperatures, by George F. Sager. 1927.

No. 21. The Thermal Conductivities of Copper and Nickel, and Some Alloys of Nickel, by W. C. Ellis, F. L. Morgan, and G. F. Sager. 1928.

No. 22. The Radiation Characteristics of Grounded Vertical, "L", and "T" Antennas, by Lester Hochgraf. 1929.

No. 23. A Study of the Color Sensitiveness of Various Types of Photo-Electric Cells, by Wendell Frederick Hess. 1929.

No. 24. Suspension Bridge Analysis by the Exact Method, Simplified by Knowledge of Its Relations to the Approximate Method, by Arvid H. Baker. 1928.

No. 25. The Engineer and the Intellectual Life, by Palmer C. Ricketts. 1929.

Live Research Projects

Department of Mechanical Engineering

1. Investigation of the Size of Riser for a Hot Water Heating System.
2. Determination of the Heat Transfer Rate in a Unit Heater.
3. Investigation of the Effect of Firebox Proportions on the Efficiency of an Oil Burning House Boiler.
4. Effect of Relative Humidity on Textiles.
5. Experiments on Heat Transfer from Hot Air to Water through Steel Pipes.
6. Experiments on Heat Transmission Coefficients through Commercial Magnesia Pipe Coverings.
7. Effect of Different Colored Paints on the Heat Radiated from a Steam Radiator.

Department of Civil Engineering

1. The Effect of Colloidal Clay on the Permeability of Concrete.
2. The Effect of Colloidal Clay on the Strength and Weathering Resistance of Concrete.
3. Investigation of the Internal Stresses Produced by Fillet Welds Made by the Metallic Arc.
4. Investigation of the Effect of Temperature on the Physical Properties of Ice.
5. Investigation of Free Running Speed of Testing Machines and the Rate of Elongation of Test Specimens.
6. Investigation of the Physical Properties and Weathering of Structural Slate.
7. Investigation of the Torsional Strength of the Metals at High Temperature.

Department of Chemical Engineering

1. The Synthesis of Substituted Phenyl Acetronitriles.
2. The Formation of Pyrrolines by the Rearrangement of Gamma-chloropropyl and Cyclopropyl Ketimines.
3. A Study of the Structure of Pyrroline and Some of Its Substituted Derivatives.
4. Reactions in Liquid Ammonia.
5. Pyrolysis of Organic Compounds.
6. Catalytic Reduction.
7. Synthesis of Sundry Imino Esters and Ketimines and the Study of Their Stability.
8. Reaction Velocity, Organic Compounds.
9. Determination of Hydrolysis and Affinity Constants of Sundry Salts and Bases.

10. Synthesis of Sundry Heterocyclic Nitrogen Ring Bases.
11. A Study of the Stability of Sundry Ring Systems.
12. Sundry Grignard Syntheses.
13. Reaction Velocities in Mixed Solvents.
14. Electrical Conductance, Microstructure and Expansion of Duriron Alloys.
15. Preparation of Single Crystals of Metallic Compounds.
16. Properties of Modified Silumin Alloys.
17. Oil-in-Water Emulsions with Carbon Black as Emulsifier.
18. Preparation and Properties of Metallic Zirconium.
19. Investigations on Gasolines.
20. Investigation of Wool Scouring.
21. Equilibrium in the Water Gas Reaction.
22. Corrosion of Alloys.
23. Physical-Chemical Studies of Methods for Separation of Zinc and Cadmium.
24. Driers and Linseed Oil.
25. Recovery of Zinc from Pickling Liquors.
26. The Study of Double Salts.
27. Absorption Spectra of Cobalto Hexamino Chlorides.
28. The Analytical Determination of Cadmium in the Presence of Zinc.
29. Electrical Conductivity of Dry Salts.

Department of Electrical Engineering

1. The Distribution of Luminous Flux in the Spectra of Neon and Mercury Arc Lamps.
2. The Characteristics of Recent Types of Fractional Horse Power Condenser Type Motors.
3. Heat Transfer from Electric Heating Units.
4. The Relation between Illumination and the Accuracy and Speed of Vision.
5. Solid Rectifiers.
6. Thermal E.M.F. of Alloys.
7. Thermal Conductivity of Alloys.
8. Physical Properties of Nickel Chromium Alloys in the Range of Stainless Steels.
9. Magnetic Properties of Iron Chromium Alloys.
10. On Refractory Materials for Cutting Tools and Dies.
11. On Improvement of Spark Plug Alloys.
12. On Improvements in Metallurgical Practice in the Separation of Iron and Copper in Nickel Ores.
13. On the Method of Separating Zinc and Cadmium in the Baghouse Fume in Lead Smelters.
14. Characteristics of Recent Types of Induction Watt-Hour Meters.
15. Characteristics of a New Type of Relay.
16. Thermal Conductivity of the Ores of Iron Nickel Alloys.
17. Transformer Starting Transients.
18. High Percentage Modulation Systems.
19. High Power Distortionless Amplification.
20. High Frequency Power Transmission.
21. Development of a New Method for the Study of Spectral Fine Structure.
22. The Determination of the Relation between the Refractory Power and Thickness of Thin Metallic Films.
23. The Effect of Fine Slits on the Intensity of Plane Polarized Light.

DEPARTMENT OF PHYSICS

1. Radiographic Examination of Castings and Various Structures.
2. Crystal Analyses of Alloys.
3. Spectroscopic Analyses of Materials and Light Sources.
4. The Roman Effect.

UNIVERSITY OF ROCHESTER, Rochester. Rush Rhees, President; Joseph W. Gavett, Jr., Professor of Mechanical Engineering.

No engineering research organization.

No engineering research reported.

SYRACUSE UNIVERSITY, Syracuse. Charles Wesley Flint, Chancellor; Louis Mitchell, Dean of the College of Applied Science.

No engineering research organization.

Live Research Projects

1. Solution of the Problem of Topographic Mapping from Comparator Measurements on Aerial Photographs. Earl Church. In press.
2. Topographic Mapping from Aerial Photographs by Means of the Stereocomparator. Earl Church.

UNION COLLEGE, Schenectady. Frank Parker Day, President; Hugh Miller, Professor of Civil Engineering; Ernst Julius Berg, Professor of Electrical Engineering.

No engineering research organization, but all engineering departments have some research work going on under the direction of individual professors.

NORTH CAROLINA

DUKE UNIVERSITY, Durham. William P. Few, President; William H. Wannamaker, Dean of the College of Arts and Sciences.

No engineering research organization.

No engineering research reported.

THE UNIVERSITY OF NORTH CAROLINA, Chapel Hill. Harry Woodburn Chase, President; G. M. Braune, Dean of the School of Engineering.

No engineering research organization.

Funds Available for 1929–1930: Allotment by University authorities, $500; grants from other sources, $1,500.

Employees for 1929–1930: Part time, 17, estimated equivalent to 3½ full time.

Channels of Publication: Proceedings of national and state engineering societies, and the technical press.

Engineering Research Circulars Published

No. 1. A Proposed Formula for Columns, by T. F. Hickerson. Reprint from *Proc. A. S. C. E.*, May, 1928.

No. 2. Reduction of Biochemical Oxygen Demand of Sewage by Chlorination, by H. G. Baity and F. M. Bell. Reprinted from *Journal North Carolina Water and Sewage Works Association*, November, 1928.

No. 3. Earth Pressure Experiments on Culvert Pipe, by G. M. Braune, William Cain, and H. F. Janda. Reprinted from *Public Roads*, November, 1929.

Live Research Projects

Project No. 1. Further Research Experimentation in Earth Pressures on Culvert Pipes. G. M. Braune and others.

Project No. 2. Improved Methods of Analyzing and Classifying Filter Sands. Thorndike Saville, with R. M. Trimble.

Project No. 3. Studies on the Mechanical Analysis of Sands. Thorndike Saville, with R. M. Trimble.

Project No. 4. Mechanical Analyses of Beach Sands and Their Significance. Thorndike Saville.

Project No. 5. Studies in North Carolina Rainfall. Thorndike Saville.

Project No. 6. Frequency and Duration Curve Studies of Stream Flow. Thorndike Saville, with Fred Merryfield.

Project No. 7. Frequency of Flood Flows on North Carolina Streams. Thorndike Saville.

Project No. 8. Evaporation from North Carolina Reservoirs. Thorndike Saville.

Project No. 9. Correlation between Rainfall, Runoff, Forest Cover, Silting, and Evaporation at Lake Michie, Durham, N. C. Thorndike Saville.

Project No. 10. A Tabular Analysis for Bending Moment in Continuous Beams and Frames. T. F. Hickerson.

Project No. 11. The Effect of Prechlorination of Sewage on the Physical, Chemical and Bacterial Quality of the Receiving Stream. H. G. Baity, Fred Merryfield, and A. B. Uzzle.

Project No. 12. The Effect of Textile Wastes on Domestic Sewage Treatment Processes. H. G. Baity.

Project No. 13. Chemical Precipitation of Textile Wastes for Removal of Color and Pollutional Constituents. H. G. Baity.

Project No. 14. Studies on the Precipitation and Digestion of Solids from Sewage Containing High Grease Content. H. G. Baity, Fred Merryfield, and A. B. Uzzle.

Discontinued or Completed Engineering Research Projects

which resulted in valuable data not published in bulletins or circulars, but available

No. 1. Factors Governing the Aerobic Decomposition of Sewage Sludge Deposits. H. G. Baity. Thesis on file in Division of Hydraulic and Sanitary Engineering.

No. 2. The Effect of Temperature and Reaction on Sewage Sludge Digestion. H. G. Baity. Thesis on file in Division of Hydraulic and Sanitary Engineering.

No. 3. Studies on Heat Production in the Digestion of Sewage Sludge. H. G. Baity. Thesis on file in Division of Hydraulic and Sanitary Engineering.

No. 4. Studies on Textile Wastes—Quantities, Characteristics and Effects on Sewage Treatment Processes. H. G. Baity and Albert M. Worth. Thesis on file in Division of Sanitary Engineering. Abstract published in *Journal North Carolina Water and Sewage Works Association*, Vol. 6, No. 1, 1928.

No. 5. Mechanical Analyses of Filter Sands. Thorndike Saville and M. A. Hill. Thesis on file in Division of Hydraulic and Sanitary Engineering.

No. 6. Rainfall in North Carolina. Thorndike Saville and R. H. Morton. Thesis on file in Division of Hydraulic and Sanitary Engineering.

No. 7. Rainfall in North Carolina. Thorndike Saville and F. M. Bell. Thesis on file in Division of Hydraulic and Sanitary Engineering.

No. 8. Report on Water Powers of New River, North Carolina. Thorndike Saville and C. E. Ray. Thesis on file in Division of Hydraulic and Sanitary Engineering.

No. 9. A New Field Method for Locating Circular Curves by Deflections from the P.I. T. F. Hickerson. *Engineering and Contracting Magazine* and *Public Roads;* also a complete set of tables printed by the Seeman Printery, Durham, N. C. 1920.

No. 10. Highway Curves and Earthwork. T. F. Hickerson. Book published by McGraw-Hill Book Co., New York. 1926.

No. 11. The Point as Compared with the Slug as a Unit of Mass. T. F. Hickerson. *Journal* of the S. P. E. E., and the *Journal of the Elisha Mitchell Scientific Society.* 1928.

No. 12. A Proposed Column Formula. T. F. Hickerson. *Proceedings* of the American Society of Civil Engineers. 1928.

No. 13. Theoretical Analysis of Fine Aggregates. R. M. Trimble. Thesis, 1927.

No. 14. Gravity Coordinates as a Measure of Sand Size and Grading. R. M. Trimble. Thesis, 1927. (Subsequent work.)

No. 15. Investigation of Shape of Grain of Fine Aggregates as Related to Mechanical Analysis. A. R. Hollett. Report, Department of Civil Engineering. May 30, 1929.

No. 16. Design of a Laboratory Culvert Testing Apparatus for Correlation of Field Data Obtained at the University of North Carolina. A. R. Hollett. Report, Department of Civil Engineering. Feb. 1, 1930.

No. 17. Experimental Determination of the Coefficients of Friction and Cohesion in Soils as Affected by the Shape and Direction of Pull of the Containing Test Vessel. C. H. Feltner. Report, Department of Civil Engineering. May 30, 1929.

No. 18. The Victaulic Pipe Joint. Thorndike Saville. *Journal* of the American Water Works Association. November, 1928.

No. 19. The Cause and Prevention of Red Water Troubles. T. Saville. Bulletin, N. C. Sec., American Water Works Association. Reprinted, *Engineering and Contracting,* February and March, 1926. Also reprinted in *Bulletin of Hygiene* (London), July and August, 1926.

No. 20. The Fineness Modulus for Filter Sands, with R. M. Trimble. *Journal* New England Water Works Association. November, 1925.

No. 21. The Power Situation in the Southern Appalachian States. *Manufacturers' Record,* April 21 and 28, 1927. Reprinted as separate by Southern Appalachian Power Conference.

NORTH DAKOTA

UNIVERSITY OF NORTH DAKOTA, Grand Forks. Thomas F. Kane, President; Elwyn F. Chandler, Dean of the College of Engineering; Alfred W. Gauger, Director of the Division of Mines and Mining Experiments.

Engineering Research Organization: Division of Mines and Mining Experiments, created by the legislature, 1907.

Funds Available for 1929–1930: Direct appropriation by legislature, $7,000; allotment by University authorities, $1,000; grants from other sources, $2,800.

Employees for 1929–1930: Full time, 1; part time, 10, estimated equivalent to 7 full time.

Channels of Publication: Bulletins and Circulars, and the technical press.

Engineering Research Bulletins and Circulars Published

* 1. First Biennial Report. Geological Survey of North Dakota.
2. Water Resources of the Devils Lake Region.
* 3. Gas Production from Lignite Coal.
* 4. Clays of Economic Value of North Dakota.
5. Soils and Sugar Beets.
* 6. Investigations of Kerosene and Gasoline.
* 7. Economic Utilization of Lignite Coal.
* 8. Investigations of Lignite Coal Relative to the Production of Gas and Briquets.
9. Economic Methods of Utilizing Western Lignites. U. S. Bureau of Mines Bulletin 89.
* 10. Better Utilization of Non-Coking Low Grade Coals.
* 11. Storing and Burning of Lignite.
* 12. Coals and Clays of North Dakota.
13. Production and Briquetting of Carbonized Lignite. U. S. Bureau of Mines Bulletin No. 221.
14. The Influence of Inorganic Materials on Lignite Carbonization.
15. A High Temperature Psychrometric Chart. Bulletin No. 10.
16. Geology and Natural Resources of North Dakota. Bulletin No. 11.
17. Pottery from North Dakota Clays. Division of Mines Circular No. 1.

Live Research Projects

1. Coking of Lignite. A. W. Gauger and assistants.
2. Combustion of Pulverized Lignite. R. L. Sutherland.
3. Boiler Tests Using Lignite. R. L. Sutherland.
4. Vapor Pressure of Lignite. Irvin Lavine.
5. Drying of Lignite with Waste Furnace Gases. R. L. Sutherland.
6. Drying of Lignite with Saturated Steam. Irvin Lavine.
7. Spontaneous Combustion of Lignite. A. W. Gauger and George A. Brady.
8. Hydrogen-Ion-Viscosity Relationships in Clay Slips. A. W. Gauger and Freida Hammers.
9. Tests of North Dakota Clays for Ceramic Wares. W. E. Budge.
10. Disintegration of Cereal Straw for Use as Briquet Binder. A. W. Gauger and Conrad Ulmen.
11. X-Ray Studies of Lignite and Coke. L. C. Harrington.

OHIO

UNIVERSITY OF AKRON, Akron. George F. Zook, President; Fred E. Ayer, Dean of the College of Engineering and Commerce.

No engineering research organization.

No engineering research reported.

* Out of print.

ANTIOCH COLLEGE, Yellow Springs. Arthur E. Morgan, President; B. M. Jones, Professor of Electrical Engineering; C. S. Adams, Director of the Antioch Industrial Research Institute.

Engineering Research Organization: Antioch Industrial Research Institute, incorporated by the Board of Trustees and Faculty, 1930.

Funds Available for 1929–1930: Grants from outside sources for research, $40,000; for equipment, $50,000.

Employees for 1929–1930: Full time, 1; part time, 10, estimated equivalent to 4 full time.

Channels of Publication: The technical press.

The Institute was but recently financed and is just getting under way. The only publications heretofore are personal papers of faculty members. The Institute has taken over unfinished research work that has been under way for six years.

CASE SCHOOL OF APPLIED SCIENCE, Cleveland. William E. Wickenden, President; Theodore M. Focke, Dean of the Faculty.

No designated organization for engineering research. Each department acts in this matter on its own responsibility. No staff members devote full time to such work.

UNIVERSITY OF CINCINNATI, Cincinnati. Herman Schneider, President; Robert C. Gowdy, Acting Dean of the College of Engineering and Commerce.

Engineering Research Organization: The College of Engineering and Commerce does not carry on any general industrial research program in its various departments. The various members of the faculty at times are engaged on specific problems of interest to them, and many senior theses are along lines of investigations suggested by their contacts with the industries.

The major portion of the research done in connection with the College of Engineering and Commerce is carried on by the Institute of Scientific Research, which consists of a number of laboratories under special directors and financed, for the most part, outside of the regular University budget. Among these laboratories are those of leather research, lithographic research, basic science research, and sound research.

UNIVERSITY OF DAYTON, Dayton. Bernard T. Schad, Professor of Civil Engineering.

No engineering research organization.

No engineering research at present.

OHIO NORTHERN UNIVERSITY, Ada. Robert Williams, President; John A. Needy, Dean of the College of Engineering.

No engineering research organization.

No engineering research reported.

OHIO UNIVERSITY, Athens. Elmer Burritt Bryan, President; Edwin Watts Chubb, Dean of the College of Liberal Arts; Lewis J. Addicott, Professor of Civil Engineering; Albert A. Atkinson, Professor of Physics and Electrical Engineering.

No engineering research.

THE UNIVERSITY OF THE CITY OF TOLEDO, Toledo. Henry J. Doermann, President.

No engineering research organization.

No engineering research.

OKLAHOMA

THE UNIVERSITY OF OKLAHOMA, Norman. W. B. Bizzell, President; J. H. Felgar, Dean of the College of Engineering.

No distinct engineering research organization.

Funds Available for 1929–30: Allotment by University authorities, $1,500; grants from other sources, $3,600.

Employees for 1929–30: Part time, 6, estimated equivalent to 2 full time.

Channels of Publication: University publications, Oklahoma Geological Survey Bulletins, Proceedings of the Southwestern Gas Measurement Short Course, and proceedings of national engineering societies.

Live Research Projects

SCHOOL OF ELECTRICAL ENGINEERING

1. Theoretical and Experimental Study of Telephone Transmission Line Phenomena. Thesis by Earl L. Hassler.
2. Experimental Temperature Study of Underground Transformer Vaults. In cooperation with the Oklahoma Gas and Electric Company, which furnished funds for building the experimental vault on the University campus. Results to be presented in Thesis form. This study will probably be continued for two more years.
3. Experimental Study of Television. Started this year as a thesis subject and to be continued next year.
4. Experimental Study of Piezo-Electric Resonators. Thesis subject, to be continued as long as desirable.

SCHOOL OF PETROLEUM ENGINEERING

1. The Effect of Natural Gas in Recovery of Oil. A. P. I. Project No. 33.
2. Study of Oklahoma Asphalts.
3. Study of Paraffin Wax.
4. Study of Mud Fluids Used in Oil Wells.

All Petroleum Engineering projects are published by A. I. M. M. E. or A. P. I.

SCHOOL OF MECHANICAL ENGINEERING

1. Study of the Efficiency of Various Kinds of Heat Insulating Materials.
2. Air-Gas Lift as Applied to Oil Wells.

3. A Study of Sucker Rod Trouble as Encountered in Oil Wells.
4. Study of Anti-Knock Qualities of Gasoline.

PENNSYLVANIA

BUCKNELL UNIVERSITY, Lewisburg. Emory William Hunt, President; Romeyn Henry Rivenburg, Dean of the College.

No engineering research organization.

Some small projects of research nature are carried on from time to time by the various branches of the engineering divisions of the College.

CARNEGIE INSTITUTE OF TECHNOLOGY, Pittsburgh. Thomas Stockham Baker, President; William Elton Mott, Director of the College of Engineering; Francis M. Walters, Jr., Director of the Bureau of Metallurgical Research.

Engineering Research Organization: Bureau of Metallurgical Research, created by the Board of Trustees, 1924.

Funds Available for 1929–30: Allotment by University authorities, $17,000; grants from other sources, $1,500.

Employees for 1929–30: Full time, 14; part time, 9, estimated equivalent to 6 full time.

Channels of Publication: Bulletins and Reprints of the Mining and Metallurgical Investigations, and the technical press.

Bulletins of the Mining and Metallurgical Investigations

Bulletin No. 1. The Yield and Quality of Gas, Oil and Other By-Products of the Constituents of the Freeport Coal Bed, Pennsylvania, by J. D. Davis, Fuels Chemist, U. S. Bureau of Mines, and Henry G. Gerger, Research Fellow, Carnegie Institute of Technology, 1922. 43 pages and 11 illustrations. Thirty-five cents.

* *Bulletin No. 2.* A Microscopic Study of the Freeport Coal Bed, Pennsylvania, by Reinhardt Thiessen, Research Chemist, U. S. Bureau of Mines, and Anson W. Voorhees, Research Fellow, Carnegie Institute of Technology, 1922. 75 pages and 44 illustrations. Thirty cents.

* *Bulletin No. 3.* Some Factors in the Spontaneous Combustion of Coal, by J. D. Davis, Fuels Chemist, U. S. Bureau of Mines, and John F. Byrne, Research Fellow, Carnegie Institute of Technology, 1922. 38 pages and 9 illustrations. Twenty-five cents.

* *Bulletin No. 4.* Corrosion Test on Metals and Alloys in Acid Water from Coal Mines, by W. A. Selvig, Assistant Analytical Chemist, U. S. Bureau of Mines, and G. M. Enos, Research Fellow, Carnegie Institute of Technology, 1922. 71 pages and 47 illustrations. Forty cents.

* *Bulletin No. 5.* Microstructural Aspects of Metals and Alloys Corroded by Acid Mine Waters, by Robert J. Anderson, Metallurgist, U. S. Bureau of Mines, 1923. 44 pages and 52 illustrations. Twenty-five cents.

Bulletin No. 6. Accelerated Corrosion Tests of Metals and Alloys in Acid Mine Water, by R. J. Anderson, Metallurgist, and G. M. Enos, Junior Metallurgist, U. S. Bureau of Mines, and J. R. Adams, Research Fellow, Carnegie Institute of Technology, 1923. 61 pages and 15 illustrations. Forty cents.

* Out of print.

Bulletin No. 7. A Study of the Desulphurization of Coke, by A. R. Powell, Associate Chemist, U. S. Bureau of Mines, and J. H. Thompson, Research Fellow, Carnegie Institute of Technology, 1923. 56 pages and 17 illustrations. Thirty cents.

Bulletin No. 8. The Low-Temperature Carbonization of Pennsylvania Coals, by J. D. Davis, Fuels Chemist, U. S. Bureau of Mines, and V. F. Parry, Research Fellow, Carnegie Institute of Technology, 1923. 56 pages and 22 illustrations. Forty cents.

Bulletin No. 9. Correlation of the Coal Beds in the Monongahela Formation in Ohio, Pennsylvania, and West Virginia, by Reinhardt Thiessen, Research Chemist, U. S. Bureau of Mines, and J. N. Staud, Research Fellow, Carnegie Institute of Technology, 1923. 64 pages and 34 illustrations. Forty cents.

Bulletin No. 10. Correlation of Coal Beds of the Allegheny Formation of Western Pennsylvania and Eastern Ohio, by Reinhardt Thiessen, Research Chemist, U. S. Bureau of Mines, and Ford E. Wilson, Research Fellow, Carnegie Institute of Technology, 1924. 56 pages and 43 illustrations. Forty cents.

Bulletin No. 11. Efficiency in Blasting of Coal; Production of Lump Coal, by J. E. Tiffany, Explosives Testing Engineer, U. S. Bureau of Mines, and C. W. Nelson, Research Fellow, Carnegie Institute of Technology, 1924. 48 pages and 23 illustrations. Fifty cents.

Bulletin No. 12. Rate of Combustion of Coal-Dust Particles: Part I—Size Classification of Finely Powdered Coal by Air Currents, by Craig M. Bouton, Associate Research Chemist, U. S. Bureau of Mines, and J. Malcolm Pratt, Research Fellow, Carnegie Institute of Technology, 1924. 42 pages and 22 illustrations. Thirty-five cents.

Bulletin No. 13. Mine-Car Friction, as Influenced by Wheel Diameter and Other Variables, by Mayo D. Hersey, Physicist, U. S. Bureau of Mines, and Howard E. Wetzel, Research Fellow, Carnegie Institute of Technology, 1924. 37 pages and 13 illustrations. Fifty cents.

Bulletin No. 14. Use of Carbon-Monoxide Gas Masks in Mines, by S. H. Katz, Associate Physical Chemist, and G. S. McCaa, Mine Safety Engineer, U. S. Bureau of Mines, and A. L. Barth, Research Fellow, Carnegie Institute of Technology, 1924. 76 pages and 16 illustrations. Forty cents.

Bulletin No. 15. Effect of Acidity and Oxidation Capacity on Corrosion of Metals and Alloys on Acid Mine Water, by Ralph E. Hall, Physical Chemist, U. S. Bureau of Mines, and William W. Teague, Research Fellow, Carnegie Institute of Technology, 1924. 61 pages and 8 illustrations. Forty cents.

Bulletin No. 16. Washing Characteristics of Coal from the Thick Freeport Bed, Pennsylvania, by H. F. Yancey, Associate Chemist, U. S. Bureau of Mines, 1924. 44 pages and 12 illustrations. Thirty cents.

* *Bulletin No. 17.* Mechanical Loading in Coal Mines, by F. E. Cash, Mining Engineer, U. S. Bureau of Mines, and E. H. Johnson, Research Fellow, Carnegie Institute of Technology, 1925. 113 pages and 54 illustrations. One dollar.

Bulletin No. 18. Methods and Costs of Rock-Dusting Bituminous Coal Mines, by C. W. Owings, Assistant Coal Mining Engineer, U. S. Bureau of Mines, and C. H. Dodge, Research Fellow, Carnegie Institute of Technology, 1925. 198 pages and 59 illustrations. $1.50.

Bulletin No. 19. Factors Influencing the Production of Lump Coal, by J. E. Tiffany, Explosives Testing Engineer, U. S. Bureau of Mines, and B. L. Lubelsky, Research Fellow, Carnegie Institute of Technology, 1925. 94 pages and 34 illustrations. One dollar.

Bulletin No. 20. Mine-Car Friction, with Six Types of Trucks, by M. D. Hersey, Physicist, and P. L. Golden, Aide, U. S. Bureau of Mines, and M. S.

* Out of print.

Downes and Henry Shore, Research Fellows, Carnegie Institute of Technology, 1925. 35 pages and 6 illustrations. Fifty cents.

Bulletin No. 21. Quantitative Mineralogical Analysis of Rock-Dusting Materials and Survey of Some Coal-Measure Shales of Western Pennsylvania, by Alden H. Emery, Assistant Geologist and Petrographer, U. S. Bureau of Mines, and R. DeChicchis, Research Fellow, Carnegie Institute of Technology, with a chapter, Chemical Analysis of Rock-Dusting Materials, by W. A. Selvig, Associate Chemist, U. S. Bureau of Mines, 1925. 77 pages and 9 illustrations. One dollar.

Bulletin No. 22. Rate of Combustion of Coal-Dust Particles: Part II—Effect of Particle Size on Pressure Increase Attending the Flammation of Coal Dust, by C. M. Bouton, Associate Research Chemist, U. S. Bureau of Mines, and J. H. Hayner, Research Fellow, Carnegie Institute of Technology, 1925. 24 pages and 8 illustrations. Fifty cents.

Bulletin No. 23. Service Conditions of Refractories for Open-Hearth Steel Furnaces, by B. M. Larsen, Assistant Metallurgist, and F. W. Schroeder, Assistant Chemist, U. S. Bureau of Mines, and E. N. Bauer and J. W. Campbell, Research Fellows, Carnegie Institute of Technology, 1925. 127 pages and 37 illustrations. $1.50.

* *Bulletin No. 24.* A Physico-Chemical Study of Scale Formation and Boiler-Water Conditioning, by R. E. Hall, Physical Chemist, U. S. Bureau of Mines; G. W. Smith and H. A. Jackson, Chemical Engineers, Hagen Corporation; and J. A. Robb, H. S. Karch, and E. A. Hertzell, Research Fellows, Carnegie Institute of Technology, 1926. 239 pages and 42 illustrations. $2.00.

Bulletin No. 25. The Effect of Phosphorus on the Resistance of Low Carbon Steel to Repeated Alternating Stresses, by F. F. McIntosh, Professor of Metallurgy, and W. L. Cockrell, Research Fellow, Carnegie Institute of Technology, 1925. 33 pages and 24 illustrations. Fifty cents.

Bulletin No. 26. Progress Report of Mining Advisory Board to Carnegie Institute of Technology and U. S. Bureau of Mines, May 29, 1919, to May 29, 1925, by W. L. Affelder, Chairman, and Edward Steidle, Secretary, 1925. 18 pages.

* *Bulletin No. 27.* Progress Report of Metallurgical Advisory Board to Carnegie Institute of Technology and U. S. Bureau of Mines, January, 1923, to January, 1926, by T. D. Lynch, Chairman, and Edward Steidle, Secretary, 1926. 32 pages and 11 illustrations.

Bulletin No. 28. Mechanical Loading for the Coal Mines of the Pittsburgh District, by H. F. McCullough, Research Engineer, Carnegie Institute of Technology, and J. W. Paul, Chief of Coal-Mining Investigations, U. S. Bureau of Mines, 1926. 78 pages and 21 illustrations. One dollar.

* *Bulletin No. 29.* Fusibility of Coal Ash as Related to Clinker Formation, by W. A. Selvig, Associate Chemist, and P. Nichols, Fuel Engineer, U. S. Bureau of Mines; and W. L. Gardner and W. E. Muntz, Research Fellows, Carnegie Institute of Technology, 1926. 63 pages and 11 illustrations. Fifty cents.

Bulletin No. 30. The Explosibility of Methane and Natural Gas, by H. F. Coward, Principal Assistant, Safety in Mines Research Board, Great Britain; G. W. Jones, Associate Chemist, U. S. Bureau of Mines; and C. G. Dunkle and B. E. Hess, Research Fellows, Carnegie Institute of Technology, 1926. 42 pages and 14 illustrations. Fifty cents.

Bulletin No. 31. Composition of Light Oils from Low-Temperature Carbonization of Utah Coals, by R. L. Brown, Organic Chemist, U. S. Bureau of Mines, and R. B. Cooper, Research Fellow, Carnegie Institute of Technology, 1926. 15 pages and 3 illustrations. Fifteen cents.

Bulletin No. 32. Certain Relations between Refractories Service, Insulation and the Flow of Heat in the Open-Hearth Furnace, by B. M. Larsen, Assistant

* Out of print.

Metallurgist, U. S. Bureau of Mines, and A. Grodner, Research Fellow, Carnegie Institute of Technology, 1927. 20 pages and 11 illustrations. Fifteen cents.

Bulletin No. 33. Methods and Costs of Treating Mine Timber: What to Treat and What Life to Expect, by L. D. Tracy, Coal Mining Engineer, U. S. Bureau of Mines, and N. A. Tolch, Research Fellow, Carnegie Institute of Technology, 1927. 312 pages and 65 illustrations. $2.00.

Bulletin No. 34. The Physical Chemistry of Steel-Making. The Solubility of Iron Oxide in Iron, by C. H. Herty, Jr., Physical Chemist; J. M. Gaines, Jr., Assistant Physical Chemist; B. M. Larsen, Assistant Metallurgist; and W. A. Simkins, Assistant Analytical Chemist, U. S. Bureau of Mines; and R. L. Geruso and S. P. Watkins, Research Fellows, Carnegie Institute of Technology, 1927. 68 pages and 31 illustrations. Seventy-five cents.

Bulletin No. 35. Composition of Tar from Low-Temperature Carbonization of Utah Coal—I, by R. L. Brown, Organic Chemist, U. S. Bureau of Mines; and B. F. Branting, Research Fellow, Carnegie Institute of Technology, 1928. 14 pages and 2 illustrations. Fifteen cents.

Bulletin No. 36. Deoxidation with Silicon and the Formation of Ferrous-Silicate Inclusions in Steel, by C. H. Herty, Jr., Physical Chemist, U. S. Bureau of Mines, and G. R. Fitterer, Research Fellow, Carnegie Institute of Technology, and Junior Metallurgist, U. S. Bureau of Mines, 1928. 94 pages and 27 illustrations. One dollar.

* *Bulletin No. 37.* A Study of the Dickenson Method for the Determination of Non-Metallic Inclusions in Steel, by C. H. Herty, Jr., Physical Chemist, and G. R. Fitterer, Junior Metallurgist, U. S. Bureau of Mines; and J. F. Eckel, Research Fellow, Carnegie Institute of Technology, 1928. 27 pages and 4 illustrations. Fifty cents.

Bulletin No. 38. Deoxidation with Silicon in the Basic Open-Hearth Process, by C. H. Herty, Jr., Physical Chemist, U. S. Bureau of Mines, and C. F. Christopher and R. W. Stewart, Research Engineers, Carnegie Institute of Technology, 1930. 216 pages and 43 illustrations. $2.00.

Bulletin No. 39. Second Progress Report of the Metallurgical Advisory Board to Carnegie Institute of Technology and United States Bureau of Mines, by T. D. Lynch, Chairman, Edward Steidle, Secretary, 1926–1928, and J. D. Beatty, Secretary, 1928. 21 pages.

Bulletin No. 40. Second Progress Report of the Mining Advisory Board to Carnegie Institute of Technology and the United States Bureau of Mines, by W. L. Affelder, Chairman, Edward Steidle, Secretary, 1926–1928, and John D. Beatty, Secretary, 1928. 11 pages.

Bulletin No. 41. Composition of Tar from Low-Temperature Carbonization of Utah Coal—II, by R. L. Brown, Organic Chemist, U. S. Bureau of Mines, and R. N. Pollock, Research Fellow, Carnegie Institute of Technology, 1929. 13 pages and 2 illustrations. Fifteen cents.

Bulletin No. 42. Efficiency, Cost, and Safety of Storage-Battery Equipment in Bituminous Coal Mines, and Some Comparisons with Wired Transmission of Power, by C. W. Owings, Associate Mining Engineer, U. S. Bureau of Mines, and D. C. Jones, Research Engineer, Carnegie Institute of Technology, 1929. 263 pages and 42 illustrations. $2.00.

Bulletin No. 43. Sulfur Forms and Ash-Forming Minerals in Pittsburgh Coal, by W. A. Selvig, Associate Chemist, United States Bureau of Mines, and Henry Seaman, Research Fellow, Carnegie Institute of Technology, 1929. 22 pages and 1 illustration. Fifty cents.

Bulletin No. 44. Theoretical Considerations in the Electrolytic Determination of Non-Metallic Inclusions in Steel, by C. H. Herty, Jr., Physical Chemist, and

* Out of print.

G. R. Fitterer, Junior Metallurgist, U. S. Bureau of Mines, and W. E. Marshall, Jr., Research Fellow, Carnegie Institute of Technology, 1929. 26 pages and 4 illustrations. Fifty cents.

Bulletin No. 45. Abnormality in Case-Carburized Steels, by C. H. Herty, Jr., Physical Chemist, B. M. Larsen, Assistant Metallurgist, U. S. Bureau of Mines, and V. N. Krivobok, Research Metallurgist; R. B. Norton, R. E. Wiley, A. W. Sikes, and J. E. Jacobs, Research Fellows, Carnegie Institute of Technology, 1929. 70 pages and 34 illustrations. One dollar.

Bulletin No. 46. Deoxidation of Steel with Aluminum, by C. H. Herty, Jr., Physical Chemist, and G. R. Fitterer, Assistant Metallurgist, U. S. Bureau of Mines, and J. M. Byrns, Research Fellow, Carnegie Institute of Technology, 1930. 50 pages and 11 illustrations. One dollar.

Mining Research Fellows and Problems for 1929–30

1. Austin Gudmundsen: The mechanism of the burning of individual particles of pulverized fuels. D. F. Smith.*
2. B. A. Juettner: The agglutinating power of coal. J. D. Davis.*
3. W. D. Pohle: A study of the effect of fusain and related inerts on the coking properties of Pittsburgh coal. J. D. Davis.*
4. G. C. Sprunk: Chemistry of decay in relation to peat and coal formation. III. The rational analysis of a peat profile. R. Thiessen.*
5. D. A. Wallace: The plastic state of coal during coking. J. D. Davis.*

Metallurgical Research Program for 1929–30

Seven Research Fellows, three Research Engineers, three analysts and two laboratory assistants, employed by the Metallurgical Advisory Board and Carnegie Institute of Technology, and G. R. Fitterer, G. L. Frear, H. Freeman, F. A Hartgen, J. E. Conley, M. B. Royer, and L. T. Brumbaugh, of the Bureau of Mines staff, in charge of C. H. Herty, Jr., are at work on the current year's program of the Physical Chemistry of Steel Making.

1. C. F. Christopher[a]: Effect of inclusions in steel (plant work), and in charge of plant work.
2. J. E. Jacobs[a]: Effect of inclusions in steel (plant work).
3. L. D. Woodworth[a]: Deoxidation with spiegel (plant work).
4. J. F. Sanderson: In charge of analytical work.
5. B. E. Sockman: Analyst.
6. B. N. Daniloff[b]: The slag system. FeO-MnO.
7. J. A. Heidish[b]: Viscosity of slags.
8. W. O. Krebs[b]: Distribution ratio of iron oxide between slag and metal.
9. M. W. Lightner[b]: Reaction between carbon and iron oxide.
10. Helge Lofquist[b]: Slag system.
11. R. B. Meneilly[b]: Methods of determining inclusions.
12. G. T. Motok: Special analytical work.
13. D. W. Cochran: Laboratory assistant.
14. Erich Martin[b]: Deoxidation with aluminum silicon alloys.
15. W. C. Miller: Laboratory assistant.
16. G. R. Fitterer[c]: Deoxidation, and formation and identification of inclusions.
17. G. L. Frear[c]: Solubility of iron oxide, and carbon elimination.

* Bureau of Mines Investigator.
[a] Research Engineer.
[b] Research Fellow.
[c] U. S. Bureau of Mines.

18. H. Freeman *: Deoxidation with spiegel (plant work), and carbon elimination.
19. F. A. Hartgen *: Viscosity of slags and temperature measurements.
20. J. E. Conley *: Slag systems.
21. M. B. Royer *: Slag systems.
22. L .T. Brumbaugh *: Analyst.

Published Research Other Than Bulletins

By J. H. James:

1. Some New Petroleum Products. *Chemical and Metallurgical Engineering*, Vol. 26, 1922, and *Transactions of American Institute of Chemical Engineers*, Vol. XIV.
2. Engine Experiments with Oxidized Oils (with Fred C. Zeisenheim). *Chemical and Metallurgical Engineering*, Vol. 28, 1923, and *Transactions of American Institute of Chemical Engineers*, Vol. XIV.
3. A Commercial Plant for Catalytic Oxidation of Oils (with W. P. Bitler). *Chemical and Metallurgical Engineering*, Vol. 33, 1928, and *Transactions of American Institute of Chemical Engineers*, Vol. XX, 1927.
4. The Effect of the War upon the American Chemical Industries. *Proceedings of the Engineers' Society of Western Pennsylvania*, 1915.
5. The Chemical Engineering Course. *Journal of Chemical Education*, 1925.
6. Unusual Factors in Plant Location. *Transactions of American Institute of Chemical Engineers*, 1926.

By F. M. McCullough:

1. Local Sands and Gravels as Aggregates in Concrete. *Proceedings of the Engineers' Society of Western Pennsylvania*, May, 1915.
2. Tests of Poles Made of Pre-Cast Concrete Units. *Carnegie Engineer*, May, 1924.
3. A New Type of Pre-Cast Concrete. *Carnegie Engineer*, May, 1923.
4. Several reports of tests on expanded metal and its use in beams and slabs, published in various pamphlets of the Consolidated Expanded Metal Companies.

By Harry Seltz:

1. Ion Activities in Homogeneous Catalysis.
The Formation of Parachloro-Acetanilide from Acetylchloro-Amino-Benzene. *Journal of American Chemical Society*, Vol. XLIV, July, 1922.
2. Quinhydrone Electrode in Non-Aqueous Solutions.
Acidity of Mineral Oils. *Industrial and Engineering Chemistry*, 1928 (20, 542).
3. Determination of Acidity of Oils and Fats by the Quinhydrone Electrode in Non-Aqueous Solutions. *Industrial and Engineering Chemistry*, Analy. Ed., Vol. 2, Jan. 15, 1930.
4. General Chemistry. Text by McCutcheon & Seltz. D. Van Nostrand Co., 1927.

By H. A. Thomas:

1. Concrete Consistency Measured by a Simple Field Test. *Engineering News Record*, May 31, 1917.
2. Flood-Waves in Rivers. *Journal of Western Society of Engineers*, August, 1923.
3. Technical Report No. VII of Miami Conservancy District. *Hydraulics of the Miami Valley Flood-Control Project.*
4. The Tensile and Collapsing Strength of Seamless Casing. *Bulletin of American Petroleum Institute*, Vol. V, December 31, 1924.

By J. C. Warner:

1. The Effect of Grinding upon the Apparent Density of Lead Oxides. *Journal of Physical Chemistry*, Vol. 26, 1922.

* U. S. Bureau of Mines.

2. Electrolytic Preparation of Ortho-Amidophenol. *Transactions of the American Electrochemical Society*, Vol. 41, 1922.

3. Electrolytic Preparation of Ortho-Amidophenol-Effect of Cathode Materials. *Journal of Physical Chemistry*, Vol. 27, 1923.

4. Electrolytic Preparation of Para-Amidophenol. *Journal of Physical Chemistry*, Vol. 27, 1923.

5. Organic Type Inhibitors in the Acid Corrosion of Iron. *Transactions of the American Electrochemical Society*, Vol. 55, 1929.

6. General Chemistry—Problems and Laboratory Experiments. (Published privately in mimeographed form and used in General Chemistry, day and night classes, in the College of Engineering, C. I. T.)

From Bureau of Metallurgical Research:

1. A Study on the Constitution of High Manganese Steels, by V. N. Krivobok. Preprint, Tenth Annual Convention of the American Society for Steel Treating, Philadelphia, October 8 to 12, 1928. Fifty cents.

2. A Study of the Iron-Chromium-Carbon Constitutional Diagram, by V. N. Krivobok and Marcus A. Grossman. Preprint, Eleventh Annual Convention of the American Society for Steel Treating, Cleveland, September 9 to 13, 1929. Fifty cents.

3. Secondary Crystallization in Iron-Carbon Alloys, by V. N. Krivobok. Boston Convention of the American Society for Steel Treating, September, 1924.

4. Thermal Disturbances and Recrystallization in Cold-Worked Steels, by V. N. Krivobok. *Transactions of American Society for Steel Treating*, December, 1925.

5. Dendritic Crystallization and Grain Formation in Steels, by V. N. Krivobok. Preprint, Eighth Annual Convention of the American Society for Steel Treating, Chicago, September 20 to 24, 1926. Forty cents.

6. Some Characteristics of Low-Carbon Manganese Steel, by V. N. Krivobok, B. M. Larson, W. B. Skinkle, and W. C. Masters. New York Meeting, the American Institute of Mining and Metallurgical Engineers, February, 1927.

7. A Photomicrographic Study of the Process of Re-Crystallization in Certain Cold Worked Metals, by V. N. Krivobok. New York Meeting, the American Institute of Mining and Metallurgical Engineers, February, 1926.

8. The Crystal Structure of Magnesium Plumbide, by James B. Friauf. Reprint from the *Journal of the American Chemical Society*, 48, 1906 (1926).

9. A Design of a Cam for an X-Ray Spectrograph, by James B. Friauf. Reprint from the *Journal of the Optical Society of America and Review of Scientific Instruments*, Vol. II, No. 3, September, 1925.

10. The Crystal Structure of Magnesium Di-Zincide, by James B. Friauf. Reprint from *Physical Review*, pp. 34–40, Vol. 29, No. 1, January, 1927.

11. Regularities in the Arc Spectrum of Cobalt, by Francis M. Walters, Jr. Reprint from the *Journal of the Washington Academy of Sciences*, Vol. 14, No. 17, October 19, 1924.

12. Regularities in the Arc Spectrum of Nickel, by Francis M. Walters, Jr. Reprint from *Journal of the Washington Academy of Sciences*, Vol. 15, No. 5, Mar. 4, 1925.

From the Commercial Engineering Department:

1. Industrial Power (chapter) of Giant Power (The Report of the Giant Power Survey Board, published by the Commonwealth of Pennsylvania), by W. F. Rittman and S. B. Ely.

2. Industrial Power of the Pittsburgh District Outside That of the Iron and Steel Industry, by S. B. Ely and W. F. Rittman. *Mechanical Engineering*, December, 1924.

3. Electrical Power in Pittsburgh District, by W. F. Rittman and S. B. Ely. *Electrical World*, June 21, 1924.

4. Pittsburgh and Western Pennsylvania as a Power Center, by W. F. Rittman and S. B. Ely. Vol. 16, *Transactions of the American Institute of Chemical Engineers.*

5. Pittsburgh as an Industrial Center, by W. F. Rittman and J. H. James. Vol. 14, No. 9, 1922, *Journal of Industrial and Engineering Chemistry.*

6. Prosperity and Power, by S. B. Ely and W. F. Rittman. *Scientific Monthly*, June, 1925.

GETTYSBURG COLLEGE, Gettysburg. Henry W. A. Hanson, President; Frank H. Clutz, Professor of Civil Engineering; Rudolph Rosenstengel, Professor of Electrical and Mechanical Engineering.

No engineering research organization.

No engineering research reported.

LAFAYETTE COLLEGE, Easton. William Mather Lewis, President; Donald B. Prentice, Dean of Lafayette College; Eugene C. Bingham, Chairman of the Faculty Committee on Research.

Engineering Research Organization: Faculty Committee on Research, appointed by the President, 1921.

Funds Available for 1929–30: Grants from outside sources, $2,050.

Employees for 1929–30: Part time, 5, estimated equivalent to 1 full time.

Channels of Publication: Research Publications of Lafayette College, proceedings engineering societies, and the technical press.

Research Publications of Lafayette College

No. 1. The Plastometer as an Instrument for Process Control. Nov., 1922. Eugene C. Bingham, Herbert D. Bruce, and Martin O. Wolbach, Jr.

No. 2. The Drainage Error in Measurements of Viscosity by the Capillary Tube Method. Dec., 1922. Eugene C. Bingham and Henry L. Young.

No. 3. A Study of Nitrocellulose. Dec., 1922. Eugene C. Bingham and William L. Hyden.

No. 4. A Study of the Plasticity of Paint. March, 1923. Eugene C. Bingham, Herbert D. Bruce, and Martin O. Wolbach, Jr.

No. 5. A Child Portrait of Drusus Junior on the Ara Pacis. March, 1922. John R. Crawford.

No. 6. White Clay Deposits at Saylorsburg, Monroe County, Pa. June, 1922. Frederick B. Peck.

No. 7. A Study of the Fluidity Relationships in the System, Nitric Acid, Sulfuric Acid, and Water. September, 1923. Eugene C. Bingham and S. Bradford Stone.

No. 8. A New Combined Viscometer and Plastometer. June, 1923. Eugene C. Bingham and Harry A. Murray, Jr.

No. 9. Some Factors Which Affect the Plasticity of a Paint. October, 1923. Eugene C. Bingham and Alfred G. Jacques.

No. 10. Conditions Affecting the Hydrolysis of Collagen in Gelatin. Nov., 1923. Robert H. Bogue.

No. 11. Fluidity Anomalies in Refined Mineral Oils. Jan., 1924. Eugene C. Bingham and G. Raymond Hood.

No. 12. Plasticity and Elasticity. January, 1924. Eugene C. Bingham.

No. 13. The Determination of Softening Temperatures by the Fluidity Method. March, 1924. Eugene C. Bingham.

No. 14. Influence of Light of Very Low Intensity on Phototropic Reactions of Animals. Nov., 1923. H. Keffer Hartline.

No. 15. Who Shall Go to College? 1924. W. O. Allen.

No. 16. Football and College Enrollment. July, 1922. B. W. Kunkel.

No. 17. The Representation of Colleges in Graduate and Professional Schools. 1924. B. W. Kunkel.

No. 18. Fluidity Anomalies in Refined Mineral Oils. May, 1924. Eugene C. Bingham.

No. 19. Plasticity as a Means for Control of Properties. June, 1924. Eugene C. Bingham.

No. 20. Discussion on Consistency. *Proc. Am. Soc. Test. Mats.*, 23, II (1923). Eugene C. Bingham.

No. 21. Viscous and Plastic Flow in Colloid Systems. *Colloid Behavior*, 1, 430 (1924). Eugene C. Bingham.

No. 22. Discussion on Plasticity. *J. Am. Ceram. Soc.*, 7, 375, October (1924). Eugene C. Bingham.

No. 23. The Rhe as the Absolute Unit of Fluidity. *Ind. Eng. Chem.*, 17, 47 (1925). Eugene C. Bingham.

No. 24. Plasticity in Colloid Control. *Colloid Symposium*, 2, 106 (1925). Eugene C. Bingham.

No. 25. The Shimer Filter Tube. *Ind. Eng. Chem.*, 17, 293 (1925). Eugene C. Bingham.

No. 26. Plasticity Symposium Papers. *J. Phys. Chem.*, 29, 1200–1289 (1925). Eugene C. Bingham, Harry N. Holmes, Wheeler P. Davey, Wilder D. Bancroft and L. E. Jenks, Winslow H. Herschel and R. Bulkley, S. E. Sheppard, Robert H. Bogue, Charles S. Venable, S. E. Sheppard and E. K. Carver, Carl Bergquist, Frank G. Breyer, Walter S. Crowell and Albert Saunders, Jr., E. Moness and P. M. Giesy. One dollar.

No. 27. Sulfite Liquor as a Protective Colloid. *Ind. Eng. Chem.*, 17, 952 (1925). Eugene C. Bingham, Guy F. Rolland and Guido E. Hilbert.

No. 28. Analysis of the Spectra of Thallium by Electrodeless Discharge. *Trans. Roy. Soc. Canada* (3), 19, 57 (1925). W. C. McQuarrie.

No. 29. Colloid Types. *Colloid Symposium.* Monograph V, 219 (1928). Eugene C. Bingham.

No. 30. Sand and Gravel in the Scranton Region. Bull. No. 96, Dept. Internal Affairs, Commonwealth of Pa. Freeman Ward.

No. 31. The Fluidity of Mercury. *J. Amer. Chem. Soc.*, 50, 2878 (1928). Eugene C. Bingham and Theodore R. Thompson.

No. 32. A Bibliography of Tusculum. George E. McCracken.

No. 33. Eine Methode zur Gleichzeitigen Messung von Plastizitat und Elastizitat. *Kolloid-Z.*, 47, 1 (1929). Eugene C. Bingham and J. W. Robertson.

No. 34. Some Fundamental Definitions of Rheology. *Proc. Am. Soc. Test. Mats.*, 29, II, June, 1929. Eugene C. Bingham.

No. 35. Rheology. I. The Nature of Fluid Flow. *J. Chem. Ed.*, 6, 1113 (1929). Eugene C. Bingham.

No. 36. Rheology. II. The Nature of Plastic Flow and Its Relation to Fluid Flow. *J. Chem. Ed.*, 6, 1206 (1929). Eugene C. Bingham.

No. 37. On the Nature of Flow. *Colloid Symposium Monograph* (1929). Eugene C. Bingham and Baxter Lowe.

No. 38. The Theory of Plastic Flow in the Rotation Viscometer. J. of Rheology, 1, 5 (1929). Markus Reiner.

No. 39. The General Law of Flow of Matter. *J. of Rheology*, 1, 11 (1929). Markus Reiner.

No. 40. A Wisconsin Ice Tongue in the Delaware Valley. *Am. J. Sci.*, 18, 446 (1929). Freeman Ward.

No. 41. A Study of the Fluidities and Densities of the Octyl Alcohols. The Association of Liquids. *J. of Rheology*, 1, 174 (1930). Eugene C. Bingham and Logan B. Darrall.

No. 42. Sand Gravel in the Reading Region, Pennsylvania. Bull. No. 99, Dept. Internal Affairs, Commonwealth of Pennsylvania. Freeman Ward.

No. 43. Sand and Gravel in the Altoona Region, Pennsylvania. Bull. No. 100, Dept. Internal Affairs, Commonwealth of Pa. Freeman Ward.

No. 44. House of Lords Reform since 1911. Political Science Quarterly, *44*, No. 4, December, 1929. Eugene P. Chase.

No. 45. Capillary Siphons. *J. of Rheology*, *1*, No. 2, 167 (1930). Eugene C. Bingham and Daniel Figlioli.

No. 46. The Nature of Flow. Colloid Symopsium Annual (1930). Eugene C. Bingham and Baxter Lowe.

Live Research Projects

1. Correlation of Different Methods for Measuring the Consistency of Various Very Viscous Materials. A Method for Expressing the Consistency of Such Materials in Absolute Units and Developing the Theory of Flow of Such Materials. Eugene C. Bingham and Fred C. Eaton.

2. The Investigation of the General Theory of the Flow of Matter from a Purely Theoretical Point of View. Markus Reiner.

3. A Study of Association of Liquids by the Fluidity Method, with the Purpose in Mind of Obtaining a Method for the Prediction of the Physical Properties of Liquids. Eugene C. Bingham.

4. Investigation of the Physical Properties of Slate. C. W. Macdougall.

5. An Investigation of a High Tensile Strength Cast Iron. Donald B. Prentice and W. S. Lohr.

6. A Study of the Temperature of the Two Electrodes in Electric Arc Welding. L. J. Conover.

7. Investigation of the Effect of Change in Velocity Distribution between the Entrance and Throat of a Venturi Meter upon the Meter Coefficient. E. M. Fernald.

8. Prediction of Centrifugal Fan Characteristics from Tests on Stationary Apparatus. E. M. Fernald.

9. The Influence of Inclination on the Discharge of Air from Branch Pipes. E. M. Fernald.

Discontinued or Completed Projects

which resulted in valuable data not published in bulletins but available

1. A Study of the Plasticity of Nitrocellulose Solutions and of the Methods of Its Measurement. 1921. William R. Bender.

2. I—A Comparison of the Fluidities and Specific Volumes of Six Samples of Linseed Oil from 10° to 80° Centigrade.

II—The Fluidities and Specific Volumes of Mixtures of "Nujol" and "Mineral Seal Oil" from 10° to 80° Centigrade.

III—A Study of the Properties of Nitrocellulose Solutions. 1921. William L. Hyden.

3. The Fluidity of Liquid Mixtures of Non-Associated and Chemically Inert Liquids as an Additive Property. 1921. Delbert F. Brown.

4. A Study of the Relation of Yield Value and Mobility of Paints to Their So-Called Painting Consistency. 1922. Herbert D. Bruce.

5. A Study of the Fluidity Relationships in the System Nitric Acid, Sulphuric Acid, and Water. 1922. S. Bradford Stone.

6. A New Combined Viscometer-Plastometer. 1923. Harry A. Murray, Jr.

7. Factors Affecting the Plasticity of Paints. 1923. Alfred G. Jacques.

8. A Further Study of Nitrocellulose Solutions. 1924. G. Raymond Hood.

9. The Utilization of Waste Sulfite Liquor. 1924. Guy F. Rolland.

10. I—A New Low Fluidity Standard Substance.

II—A Study of Gelatin in the Viscous and Plastic Regimes. 1925. Samuel S. C. Rich.

11. The Utilization of Waste Sulfite Liquor. 1925. Guido E. Hilbert.

12. I—The Fluidity of Non-Aqueous Mixtures.

II—The Plasticity of Sodium and the Fluidity of Dilute Sodium Amalgams. 1925. Horace E. Rogers.

13. A Study of a Second Type of Plastic Flow Using Nitrocellulose as the Dispersed Phase. 1926. Paul R. Nelson.

14. A Study of the Plasticity of Ten China Clays Using the Bingham-Murray Plastometer-Viscometer. 1926. Vinton R. Rawson.

15. The Plasticity of Clays. 1927. Leslie German.

16. The Kinetic Energy Correction in Viscometry When Using Trumpet-Shaped Capillaries, and The Viscosity of Mercury in Glass and in Copper Capillaries. 1928. Theodore R. Thompson.

17. Plastic and Elastic Properties of Ammonium Oleate Solutions. 1928. John W. Robertson.

18. The Fluidity-Specific Volume Relationships of Twenty-Two Isomeric Octyl Alcohols from 0 to 100 Degrees. 1929. Logan B. Darnall.

19. I—Correlation of the Couette-Hatschek Viscometer with the Bingham-Murray Plastometer.

II—The Flow Patterns of Polar and Non-Polar Colloids. 1929. Baxter B. Lowe.

20. The Treatment of Gases for the Removal of Suspended Particles and the Results of Electrical Precipitation in Three Different Industries. 1928. Charles E. Beaver.

UNIVERSITY OF PENNSYLVANIA, Philadelphia. Josiah Harmar Penniman, Provost; Robert H. Fernald, Dean of the Faculty of the Towne Scientific School; Harold Pender, Dean of the Faculty of the Moore School of Electrical Engineering.

Engineering research not organized on the basis of an Engineering Experiment Station nor as an independent division of research. Each of the several departments carries on its research work as seems best to the Director of the Department under the general policies adopted by the engineering schools. The many research problems are, for the most part, affiliated with industry.

No projects or publications reported.

UNIVERSITY OF PITTSBURGH, Pittsburgh. John Gabbert Bowman, Chancellor; E. A. Holbrook, Dean of the School of Engineering and of the School of Mines; Edward Ray Weidlein, Director of the Mellon Institute of Industrial Research.

Engineering Research Organization: Mellon Institute of Industrial Research, which is administratively independent of the Schools of Engineering and Mines. There is close cooperation, however.

Many of the staffs of these schools through affiliation with Mellon Institute are carrying on research work. Also, in the industrial district of Pittsburgh are a number of large organizations, including the Gulf Oil Company, U. S. Bureau of Mines, Westinghouse Electric and Manufacturing Co., Aluminum Company of America, The Koppers Company and others with which staff members find opportunity for research activities.

Funds Available: During the fiscal year ending February 28, 1930, the sum of $929,109.02 was contributed to Mellon Institute by the fellowship donors in support of research.

Number of Fellows: During the year ending February 28, 1930, 150 industrial fellows, 59 full-time fellowship assistants, and numerous part-time assistants held positions on the research staff of Mellon Institute.

Channels of Publication of Mellon Institute: Books, Bulletins, Journals and Patents.

Books by Members of Mellon Institute

1. The New Knowledge, by Robert Kennedy Duncan. A. S. Barnes and Company, New York, N. Y., 1905. 263 pp. $2.25.
2. The Chemistry of Commerce, by Robert Kennedy Duncan. Harper and Brothers, New York, N. Y., 1907. 263 pp. $2.25.
3. Some Chemical Problems of Today, by Robert Kennedy Duncan. Harper and Brothers, New York, N. Y., 1911. 254 pp. $2.25.
4. The American Petroleum Industry, by Raymond Foss Bacon and William Allen Hamor. McGraw-Hill Book Company, New York, N. Y., 1922. 2 v. 963 pp. $12.00.
5. Technical Examination of Crude Petroleum, Petroleum Products, and Natural Gas, by William Allen Hamor and Fred Warde Padgett. McGraw-Hill Book Company, New York, N. Y., 1920. 591 pp. $6.00.
6. Junior Science, Book 2, by John Charles Hessler. B. H. Sanborn and Company, Chicago, Ill., 1921. 295 pp.
7. The Conservation of Textiles, by Harvey Gerald Elledge and Alice Lucille Wakefield. Laundryowners Nat. Assoc., La Salle, Ill., 1921. 162 pp. $1.00. Second edition, 1923. 162 pp. $1.00.
8. American Fuels, by Raymond Foss Bacon and William Allen Hamor. McGraw-Hill Book Company, New York, N. Y., 1922. 2 v. 1257 pp. $12.00.
9. Chemistry and Technology of Gelatin and Glue, by Robert Herman Bogue. McGraw-Hill Book Company, New York, N. Y., 1922. 644 pp. $6.00.
10. Manual of Standard Practice for the Power Laundry Washroom, by the Industrial Fellowship of the Laundryowners National Association. Laundryowners Nat. Assoc., La Salle, Ill., 1922. 112 pp. $1.00. Second Edition, 1924. 187 pp. $1.50.
11. Textile Fabrics: Their Selection and Care from the Standpoint of Use, Wear and Launderability, by George Henry Johnson. Harper and Brothers, New York, N. Y., 1927. 385 pp. $5.00.
12. The Wealth of the Sea, by Donald Kiteley Tressler. Century Company, New York, N. Y., 1927. 340 pp. $4.00.
13. Petroleum and Its Products, by William Arthur Gruse. McGraw-Hill Book Company, New York, N. Y., 1928. 377 pp. $5.00.

Bulletins by Members of Mellon Institute

* 1. Outline of the Smoke Investigation, Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 1, Pittsburgh, Pa., 1912. 16 pp.

* 2. Papers on the Effect of Smoke on Building Materials, by Raymond Calvin Benner, Editor. Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 6, Pittsburgh, Pa., 1913. 58 pp. Twenty-five cents.

* 3. The Effect of the Soot in Smoke on Vegetation, by Joseph Franklin Clevenger. Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 7, Pittsburgh, Pa., 1913. 26 pp.

4. The Meteorological Aspect of the Smoke Problem, by Herbert H. Kimball. Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 5, Pittsburgh, Pa., 1913. 51 pp. Twenty-five cents.

5. Bibliography of Smoke and Smoke Prevention, by Ellwood H. McClelland, compiler. Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 2, Pittsburgh, Pa., 1913. 164 pp. Fifty cents.

6. The Economic Cost of the Smoke Nuisance to Pittsburgh, by John O'Connor, Jr. Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 4, Pittsburgh, Pa., 1913. 46 pp. Twenty-five cents.

7. Psychological Aspects of the Problem of Atmospheric Smoke Pollution, by J. E. Wallace Wallin. Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 3, Pittsburgh, Pa., 1913. 46 pp. Twenty-five cents.

8. Papers on the Influence of Smoke on Health, by Oskar Klotz and William Charles White, editors. Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 9, Pittsburgh, Pa., 1914. 173 pp. Fifty cents.

9. Industrial Fellowships in the Mellon Institute of Industrial Research, Pittsburgh, Pa., 1914. 15 pp.

10. Some Engineering Phases of Pittsburgh's Smoke Problem, Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 8, Pittsburgh, Pa., 1914. 193 pp. Fifty cents. Published in condensed form in *Power*, 40 (1914), 344–345.

11. The Cost of Living Studies in Pittsburgh, by John O'Connor, Jr. Pittsburgh, Pa., 1914.

12. Service to Industry, Pittsburgh, Pa., 1915. 12 pp.

13. Mellon Institute Processional, by Lois Whittle. Pittsburgh, Pa., 1915.

14. Five Years' Progress in the Industrial Fellowship System, Pittsburgh, Pa., 1916. 3 pp.

15. The Growth of the Industrial Fellowship System, Pittsburgh, Pa., 1917. 4 pp.

16. The Collaboration of Science and Industry, by Victor Grignard. Pittsburgh, Pa., 1918. 7 pp.

17. The Growth of the Industrial Fellowship System, Pittsburgh, Pa., 1918. 4 pp. Reprinted in *J. Ind. Eng. Chem.*, 10 (1918), 401–402.

18. Laundryowners National Association Standard Formulas for Washroom Practice, Charts Nos. 1, 2 and 3. Laundryowners Nat. Assoc., La Salle, Ill., 1919. Second edition, 1924.

19. Procedure Chart for the Removal of Stains from Wash Goods, Pittsburgh, Pa., 1919.

20. Coal and By-Products, a Special Field of Laboratory Investigation, Research Laboratories of the Koppers Company. Pittsburgh, Pa., 1919. 23 pp. Published in condensed form under the title "Research Laboratories for Coal and By-Products," *Gas Age*, 44 (1919), 281–288.

21. Seventh Annual Report on the Industrial Fellowships of the Mellon Institute for the Fiscal Year Ended February 29, 1920, by Raymond Foss Bacon. Pittsburgh, Pa., 1920. 24 pp.

* Out of print.

22. Eighth Annual Report on the Industrial Fellowships of the Mellon Institute for the Fiscal Year Ended February 28, 1921, by Raymond Foss Bacon. 19 pp.

23. Recent Progress in Smoke Abatement and Fuel Technology in England, by Robert James McKay. Mellon Institute of Industrial Research, Smoke Investigation Bulletin No. 10, Pittsburgh, Pa., 1922. 62 pp. Fifty cents.

24. Bibliographic Bulletin No. 1, "A List of the Books, Bulletins, Journal Contributions and Patents by Members of Mellon Institute of Industrial Research, 1911–1922," Pittsburgh, Pa., 1922. 37 pp.

25. Ninth Annual Report on the Industrial Fellowships of Mellon Institute, for the Institute's Fiscal Year, March 1, 1921, to March 1, 1922, by Edward Ray Weidlein. Pittsburgh, Pa., 1922. 23 pp. Abstract, *J. Ind. Eng. Chem.*, 14 (1922), 747–748.

26. First Supplement to Bibliographic Bulletin No. 1, listed as Item 24, above. 1923. 11 pp.

27. Tenth Annual Report on the Industrial Fellowships of Mellon Institute for the Institute's Fiscal Year, March 1, 1922, to March 1, 1923, by Edward Ray Weidlein. Pittsburgh, Pa., 1923. 20 pp. Abstract, *Ind. Eng. Chem.*, 15 (1923), 538–540.

28. Removal of Stains, a chart in two parts, Laundryowners Nat. Assoc., La Salle, Ill., 1924.

29. The Selection and Conservation of Textiles, Laundryowners Nat. Assoc., La Salle, Ill., 1924. 26 pp.

30. Second Supplement to Bibliographic Bulletin No. 1, listed as Item 24, above. 1924. 16 pp.

31. Industrial Fellowships, Pittsburgh, Pa., 1924. 21 pp.

32. Acetone, Its Properties and Uses, by Raymond Frederick Remler. Nat. Wood Chem. Assoc., 1924. 26 pp.

33. The Application of Scientific Principles to the Designing of Ventilators, by James Howard Young. Mellon Institute of Industrial Research, Pittsburgh, Pa., 1924. 15 pp.

34. Condition of Floors after Continued Service, by Carl Henry Geister. Progress Report presented before the Am. Hospital Assoc., Louisville, Ky., October 22, 1925. 9 pp.

35. Laundering Colored Goods, by George Henry Johnson. Special Bull., Laundryowners Nat. Assoc., La Salle, Ill., 1925. 12 pp.

36. Third Supplement to Bibliographic Bulletin No. 1, listed as Item 24, above. 1925. 14 pp.

37. Code of Regulations of Mellon Institute of Industrial Research and Obligations of the Institutional Membership, Pittsburgh, Pa., 1925. 22 pp.

38. List of Periodicals in the Library of Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa., 1925. 19 pp. Second edition, 1926. 20 pp.

39. The Purification of Open-Hearth Fuel Gas, by Frederick William Sperr, Jr. Koppers Company, Pittsburgh, Pa., 1925. 27 pp.

40. New Apparatus for the Removal of Naphthalene and Gum-Forming Constituents from Gas, by Frederick William Sperr, Jr., and Alfred Richard Powell. Koppers Company, Pittsburgh, Pa., 1925. 19 pp.

41. A Series of Seven Radio Talks on Science in Industry: E. R. Weidlein, Science in Industry; J. B. Garner, Natural Gas; W. F. Faragher, Petroleum; F. W. Sperr, Jr., Coal and Coke; E. W. Tillotson, Glass; M. C. Booze, Clay Products; W. A. Hamor, Introduction; and select bibliographies. Radio Publication No. 9, University of Pittsburgh, 1925. 40 pp.

42. The Load Test for Fire Clay Refractories, by MacDonald Charles Booze. Am. Refractories Inst., Tech. Paper No. 2, Pittsburgh, Pa., 1926. 12 pp. Abstract, *Nat. Glass Budget*, 42 (1926), No. 29, 24.

43. Rayon, by George Henry Johnson. Special Bul., Laundryowners Nat. Assoc., La Salle, Ill., 1926. 16 pp. Abstract, *Am. Dyestuffs Reports*, 15 (1926), 807–808, 839–840.

44. Fourth Supplement to Bibliographic Bulletin No. 1, listed as Item 24, above. 1926. 11 pp.

45. Nomenclature for Refractories, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 6, Pittsburgh, Pa., 1926. 5 pp.

46. Notes on Mullite Refractories, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 7, Pittsburgh, Pa., 1926. 4 pp.

47. A Study of Tests for Refractories with Special Reference to Spalling Tests, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Paper No. 1, Pittsburgh, Pa., 1926. 27 pp.

48. The Technical Program of the Fourth Semi-Annual Meeting of the American Refractories Institute, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 4, Pittsburgh, Pa., 1926. 4 pp.

49. The Testing Division of the American Refractories Institute, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 2, Pittsburgh, Pa., 1926. 3 pp.

50. The Variation of Size Occurring in Clay and Silica Refractories, by Stuart Mortimore Phelps and Harold Foster Robertson. Am. Refractories Inst., preprint, Pittsburgh, Pa., Sept. 29, 1926. 9 pp.

51. New Method of Gas Purification, by Frederick William Sperr, Jr. Koppers Company, Pittsburgh, Pa., 1926. 20 pp.

52. A Series of Eleven Radio Talks on Science in the Home: W. A. Hamor, Preface; E. R. Harding, Food Values; R. R. Irvin, Cereal Foods; D. K. Tressler, Foods from the Sea; H. M. Johnson, Selection and Care of Beds and Bedding; R. H. Heilman, Fuel Economy in the Home; G. H. Johnson, Selection and Care of Textile Fabrics; L. E. Jackson, Renovation of Wearing Apparel; O. F. Hedenburg, Home Disinfectants and Insecticides; F. F. Rupert, Care of Tableware and Kitchen Utensils; C. H. Geister, Selection and Care of Flooring Materials; E. S. Ross, Selection of Roofing Materials. Radio Publication No. 23, University of Pittsburgh, 1926. 83 pp.

53. Impressions of Robert Kennedy Duncan, by William Allen Hamor. Mellon Institute of Industrial Research, Pittsburgh, Pa., 1927. 7 pp.

54. Bibliographic Bulletin No. 2, "A List of the Books, Bulletins, Journal Contributions, and Patents by Members of the Mellon Institute of Industrial Research, 1911–1927," by Lois Heaton. Mellon Institute of Industrial Research, Pittsburgh, Pa., 1927. 80 pp.

55. An Elementary Account of the P. C. E. or the Softening of Refractories by Heat, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 17, Pittsburgh, Pa., 1927. 4 pp.

56. The Effect of Water Content and Pressure of Repressing on the Porosity of Stiff Mud Brick, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 11, Pittsburgh, Pa., 1927. 6 pp.

57. Notes on Mullite Refractories, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 7, Pittsburgh, Pa., 1927. 6 pp.

58. Plastic Refractories, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Paper No. 3, Pittsburgh, Pa., 1927. 17 pp.

59. Studies of the Effects of Chlorine, Sulphur Dioxide and Carbon Monoxide upon the Various Refractories, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 9, Pittsburgh, Pa., 1927. 8 pp.

60. A Series of Six Radio Talks on Automobile Engines; Their Operation and Care: W. A. Hamor, Foreword, p. 3; W. A. Gruse, Introduction, p. 5–7; P. K. Porter, How the Motor Works, p. 9–13; D. R. Stevens, Chemistry of Engine Operation, p. 14–20; S. P. Marley, Engine Fuels, p. 21–29; B. L. Souther, Cooling

Systems and Dilutions, p. 30–35; C. J. Livingstone, Lubrication of the Automobile Engine, p. 36–42; C. J. Livingstone, Carbon Deposits in the Engine, p. 43–51; Radio Publication No. 28, University of Pittsburgh, 1927. 51 pp.

61. Indiana Limestone—I, Efflorescence and Staining, by Frederick Osban Anderegg, H. C. Peffer, Paul R. Judy and Lee Huber. Bul. Purdue Univ., 12 (1928), No. 6, Lafayette, Ind. 84 pp.

62. A Washwheel Timing Device, by George Henry Johnson. Special Bul., Laundryowners Nat. Assoc., 1928. 4 pp.

63. Laundryowners National Association Formulas for Washroom. Charts 1, 2, 3. Third edition. Laundryowners Nat. Assoc., La Salle, Ill., 1928.

64. Removal of Stains, a chart in two Parts. Laundryowners Nat. Assoc., La Salle, Ill., 1928.

65. High-Test Gray Iron—Part I, Introduction and Historical Review, by Edward Ellsworth Marbaker. Whiting Corporation, Chicago, Ill., 1928. 4 pp.

66. High-Test Gray Iron—Part II, Processes Developed Since 1920, by Edward Ellsworth Marbaker. Whiting Corporation, Chicago, Ill., 1928. 8 pp.

67. High-Test Gray Iron—Part III, Special Methods, by Edward Ellsworth Marbaker. Whiting Corporation, Chicago, Ill., 1928. 10 pp.

68. A List of the Books, Bulletins, Journal Contributions, and Patents by Members of Mellon Institute of Industrial Research during the Calendar Year 1927, by Lois Heaton. Mellon Institute of Industrial Research, Pittsburgh, Pa., 1928. 13 pp.

69. The Brick Meter, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 27, Pittsburgh, Pa., 1928. 6 pp.

70. An Elementary Account of the Chemical Analysis of Refractory Materials, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 14, Pittsburgh, Pa., 1927. 9 pp. Crescent Refractories Company, Series I, Bul. No. 18–19, Curwensville, Pa., 1928. 4 pp.; 5 pp.

71. Future Progress in the Field of Refractories, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 21, Pittsburgh, Pa., 1928. 7 pp.

72. A Non-Technical Description of Spalling Action, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 24, Pittsburgh, Pa., 1928. 7 pp.

73. Notes on the English and German Refractories Industry, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 25, Pittsburgh, Pa., 1928. 4 pp.

74. A Series of Seven Radio Talks on Wearing Apparel; Its Manufacture, Utility, Selection and Care: W. A. Hamor, Foreword, p. 5–6; C. F. Goldthwait, Cotton Fabrics, p. 7–13; E. R. Clark, Undergarments, p. 14–20; L. E. Jackson, Wool Clothing, p. 21–29; H. E. Wassell, Silk Garments, p. 30–37; G. H. Johnson, Rayon Goods, p. 38–44; L. E. Jackson, Furs, p. 45–52; R. R. McGregor, Hats, p. 53–60; Radio Publication No. 37, University of Pittsburgh, 1928. 60 pp. Summary, *Cleaning and Dyeing World*, 12 (1928), No. 6, 26–27.

75. Impressions of Robert Kennedy Duncan, 2d Edition, Pittsburgh, Pa., 1929. 8 pp.

76. A Practical Study of Sudsing and Rinsing Time, by Charles E. Lennox and Bernard Harold Gilmore. Special Bul., Laundryowners Nat. Assoc., March, 1929. 14 pp.

77. High-Test Gray Iron—Part IV, Review of Literature from 1920–1928, by Edward Ellsworth Marbaker. Whiting Corporation, Chicago, Ill., 1929. 8 pp.

78. A List of the Books, Bulletins, Journal Contributions, and Patents by Members of Mellon Institute of Industrial Research during the Calendar Year 1928, by Lois Heaton. Mellon Institute of Industrial Research, Pittsburgh, Pa., 1929. 11 pp.

79. The Brick Meter, by Stuart Mortimore Phelps. Am. Refractories Inst., Tech. Bul. No. 27, Pittsburgh, Pa., 1929. 6 pp.

80. An Elementary Account of the P. C. E. or the Softening of Refractories by Heat, by Stuart Mortimore Phelps. Crescent Refractories Company, Tech. Bul., Series 1, No. 22, Curwensville, Pa., 1929. 8 pp.

81. The Selection of Coals for the Manufacture of Coke, by Harold James Rose. 2d edition. Koppers Company, Pittsburgh, Pa., 1929. 42 pp.

82. Science for the Home Manager: A Series of Fourteen Radio Talks: L. W. Bass, Foreword, p. 5–6; G. D. Beal, Science and the Home, p. 7–13; R. B. Trusler, Soap, the Agent of Cleanliness, p. 14–21; O. F. Hedenburg, Extermination of Pests, p. 22–29; H. M. Johnson, The Selection of Bedding Equipment, p. 30–38; T. W. Swan, The Care of the Bedroom, p. 39–47; E. R. Harding, Foods That Are Most Healthful, p. 48–58; L. E. Jackson, Carpet and Draperies, p. 59–68; E. W. Schwartze, Selection and Care of Kitchen Equipment, p. 69–75; R. H. Heilman, Heating of the Home, p. 89–97; R. H. Heilman, Healthful Ventilation, p. 98–104; H. K. Salzberg, When Painting is Needed, p. 105–117; H. S. Coleman, Fire Risks and Prevention, p. 118–128; H. M. Marc, Residential Roofings, p. 129–135; Radio Publication No. 48, 1929. 137 pp.

Industrial Fellowships at Mellon Institute During the Fiscal Year Ended February 28, 1930

549. Chrome Ore. H. F. Robertson.

646. Synthetic Resins. B. F. Dodge and Geoffrey Robbins.

649. Surgical Supplies. H. L. Cox.

650. Cast Iron. J. D. Alley and L. W. Vollmer.

651. Cast Iron. J. D. Alley and Daniel Neuman.

653. Hat. T. R. LeCompte.

660. Aluminum. H. K. Work.

665. Air Pollution. H. B. Meller, Mary E. Warga, M. F. Benbow, Dorothy Hamilton, Eleanor M. Jones and Morris Ostrofsky.

667. Licorice. H. T. Lacey.

677B. Bed. T. H. Swan.

678. Gum. N. J. Beaber.

685. Industrial Alcohol. H. E. Foote.

695. Fur. R. R. McGregor.

696. Stearic Acid. R. B. Trusler.

698. Insulating Lumber. M. D. Coulter.

699. Cleaning. L. E. Jackson and P. L. Fasig.

700. Edible Gelatin. W. W. Duecker and W. F. Speer.

701. Portland Cement. F. O. Anderegg, D. S. Hubbell, P. F. Siegrist, R. P. Lutz, George Walther, C. H. Rasch, and D. L. Murphy.

702. Cotton Yarns. C. F. Goldthwait.

703. Rosin Oil. A. W. Johnson.

704. Dental. J. J. Enright, Mildred O. Trescher, V. S. Wrenn, and Dorothy Hamilton.

705. Pressing Machinery. E. R. Clark.

706. Carbon Black. C. W. Sweitzer, J. A. Satosky and Catherine M. Moore.

707. Refractories. S. M. Phelps, R. F. Ferguson, E. B. Read, Vance Cartright, W. R. Kerr, A. C. Hughes, S. M. Swain, G. R. Daniel, T. A. Carr, E. C. Petrie, W. J. Porter and Kenneth Lowe.

708. Milk Products. R. R. Irvin.

709. Composite Glass. T. M. Andrews.

710. Yeast. H. A. Kohman.

711. Garment. T. H. Swan.

712. Hemp Paper. T. R. LeCompte.

713. Insulating Glass. J. H. Waggoner.

714. Food Container. E. W. Morrison.

715. Protected Metals. J. H. Young, P. W. Jenkins, P. M. Snyder, H. A. Spangler, A. W. Coffman, and George Davis.

716. Inhibitor. W. E. Graham.

717. Steel Treatment. J. D. Alley.

718. Glass. E. J. Casselman.

719. Insecticide. O. F. Hedenburg.

720. Steel Products. S. A. Braley.

721. Petroleum Production. A. G. Loomis, P. D. Foote, J. L. Shereshefsky, H. A. Ambrose, J. S. Brown, A. J. Teplitz, A. E. Ruark, R. L. Chenault, B. B. Wescott, G. W. Rusler, W. O. Smith, H. G. Botset, L. W. Vollmer, Beauregard Perkins, Jr., G. L. Hassler, C. G. zur Horst, S. H. Gill, W. F. Rogers, S. U. McGary, Alfred Wolf, J. K. Rodgers, H. C. Lawton, W. T. Schelling, C. H. McLain, C. N. Bowers, Milan Meres, C. G. Heim, A. E. Vorback, H. W. Knipfer, F. E. Gallagher, P. F. Busang, F. F. Versaw, and D. W. Reed.

722. Can. R. B. McKinnis.

723. Sleep. H. M. Johnson, G. E. Weigand, S. A. Flesher, Frederick Gearhart, L. R. Clapp, C. J. Phillips, S. R. Hathaway and E. G. Cobb.

724. Petroleum Refining. W. A. Gruse, S. P. Marley, C. J. Livingstone, B. L. Souther, D. R. Stevens, John Metschl, J. W. Greene, E. B. Hjerpe, C. R. Payne, J. R. Adams, S. M. Martin, Jr., A. T. Clifford, S. M. Cooper, John Curry, E. C. Martin, L. J. Wolfe, James Doherty, J. V. Hanlon, and Harry Hipsley.

725. Velvet. G. S. Hiers.

726. Rock Products. C. H. Geister.

727. Fatty Acids (Production). R. N. Wenzel, H. H. Weber, A. C. Brown, and J. M. Henninger.

728. Natural Gas. J. B. Garner and Mason Garner.

729. Slag. Tracy Bartholomew.

730. Paper. P. B. Davidson.

731. School Supplies. F. F. Rupert.

732. Laundering. B. H. Gilmore, G. H. Johnson, and A. I. Anderson.

733. Wax. J. N. Lawrence, D. K. Tressler, Jules Labarthe, Carlisle Schade and A. F. Tesi.

734. Nicotine. N. J. Beaber.

735. Paper Finishing. Marc Darrin and Burton Love.

736. Silicate. J. L. Crawford.

737. Rosin. W. B. Burnett and H. K. Salzberg.

738. Utensil. G. J. Cox, E. W. Schwartze, Mary L. Dodds, R. B. Unangst, F. J. Murphy, R. M. Hann, Helen B. Wigman and W. H. Bradley.

739. Organic Synthesis. E. W. Reid, George Alexander, H. R. Fife, R. B. Frazier, M. C. Edwards, C. H. Atwood, H. W. Burchard, H. P. White, R. A. MacArthur, R. F. Brown, John Hayes, E. L. Meadows, J. M. Russ, Jr., and G. S. Santmyers.

740. Enamels. F. L. Jones and B. A. Rice.

741. Iodine. G. M. Karns and H. C. Donaldson, Jr.

742. Scale Manufacture. A. M. Howald and J. T. Stearn.

743. Carbonated Beverage. R. F. Beard.

744. Pigment. R. R. McClure, D. A. Miller and Walter Rupp.

745. Fertilizer. H. H. Meyers and C. M. Bible.

746. Wood By-Products. D. L. Sherk.

747. Food Varieties. E. R. Harding, Virginia L. Wallis and Helen Bright.

748. Coke. F. W. Sperr, Jr., H. J. Rose, I. H. Jones, J. A. Shaw, G. G. Desy and S. S. Cole.

749. Insulation. R. H. Heilman and R. W. Ortmiller.

750. Roofing. H. M. Marc.

751. Fatty Acids. (Uses) R. B. Trusler.
752. Oxygen. H. E. Foote.
753. Heating. J. L. Young.
754. Pharmaceuticals. A. W. Harvey.

Journal Contributions and Patents by Members of Mellon Institute

The list is too long to be given here. It can be found in Bulletin No. 2, of the Institute's Bibliographic Series, and the First, Second, and Third Supplements to that bulletin. See items 54, 68, and 77 of the list of Bulletins by Members of Mellon Institute, above. Complimentary copies of these booklets are sent to research directors, science teachers and librarians upon request.

SWARTHMORE COLLEGE, Swarthmore. Frank Aydelotte, President; Charles G. Thatcher, Chairman of the Division of Engineering.

No engineering research organization.

Live Research Project

Studies on Photoelectrochemical Reactions to Theory and Operation of Photovoltaic Cells. Dwight K. Alpern.

VILLANOVA COLLEGE, Villanova. Carl T. Humphrey, Dean of the School of Technology.

No engineering research organization.

No engineering research reported.

RHODE ISLAND

BROWN UNIVERSITY, Providence. Clarence A. Barbour, President; William H. Kenerson, Chairman of the Division of Engineering.

No engineering research organization. A considerable amount of research work is continuously being carried on in the experimental laboratories, and practically all the professors have projects on hand, either because of personal interests or for industrial concerns with which they may be connected as consultants.

No projects or publications reported.

SOUTH CAROLINA

THE CITADEL, THE MILITARY COLLEGE OF SOUTH CAROLINA, Charleston. O. J. Bond, President; L. S. LeTellier, Head of the Department of Mechanical Engineering.

No engineering research organization.

Employees for 1929–1930: Part time, 1, estimated equivalent to ¼ full time.

Live Research Projects

Project No. 1. Effect of Diatomaceous Silica on the Water-Cement Ratio of Concrete, L. S. LeTellier.

Project No. 3. Column Strength of Piles as Related to Impact of Steam Hammers. L. S. LeTellier.

Discontinued or Completed Projects

which resulted in valuable data not published in bulletins or circulars but available

Project No. 2. Lateral Loads on Timber Bridge Bents with Long Unbraced Pile Lengths. Results on file in office of Department of Engineering.

Project No. 4. Analysis of Concrete Form Displacement. A. G. Hampton. *Engineering News-Record.* March 28 and April 4, 1929.

Project No. 5. Excavating Beneath Bridge Openings as a Method of Increasing Capacity of Openings for Bridges over Wide Shallow Swamps Subject to Flooding. W. W. Wannamaker, Jr. Results on file in Department of Engineering, The Citadel.

Note: Projects 4 and 5 submitted by graduate students as theses for C.E. degree.

SOUTH DAKOTA

UNIVERSITY OF SOUTH DAKOTA, Vermilion. Lewis E. Akeley, Dean of the College of Engineering.

No engineering research organization.

No engineering research reported.

SOUTH DAKOTA STATE SCHOOL OF MINES, Rapid City. C. C. O'Harra, President.

Engineering Research Organization: Mining Experiment Station, created by the legislature in 1903.

Funds Available for 1929–1930: Direct appropriation by legislature, $3,000. Much of the work is of a routine nature and only a small part of the fund is available for research.

Channels of Publication: Bulletins, and *The Black Hills Engineer*, a quarterly magazine established December, 1911, and issued by the School. Price, one dollar per year.

Bulletins Issued by the School of Mines

* *Bulletin No. 1.* Preliminary Report of the Dakota School of Mines upon Geology, Mineral Resources and Mills of the Black Hills of Dakota, by F. R. Carpenter and H. O. Hoffman. 171 pages. 1888.

Bulletin No. 2. Notes on the Geology and Mineral Deposits of a Portion of the Southern Black Hills, by C. C. O'Harra and A. Forsyth. 41 pages. 1899.

Bulletin No. 3. Cyanide Experiments on the Siliceous Ores of the Northern Black Hills, et cetera, by A. Forsyth and G. H. Clevenger. 27 pages. 1900.

* *Bulletin No. 4.* A History of the Early Explorations and of the Progress of Geological Investigations in the Black Hills Region; and A Bibliography of Contributions to the Geology and Geography of the Black Hills Region, by C. C. O'Harra. 88 pages. 1900. For later and more complete bibliography see Bulletin No. 11.

* *Bulletin No. 5.* The Cyanide Process in the Black Hills of South Dakota, by C. H. Fulton. 88 pages. 1902.

* Out of print.

* *Bulletin No. 6.* The Mineral Wealth of the Black Hills, by C. C. O'Harra. 88 pages. 1902.

Bulletin No. 7. Metallurgical Practice in the Black Hills of South Dakota, by C. H. Fulton. 63 pages. 1904.

Bulletin No. 8. The Cement Resources of the Black Hills, by C. C. O'Harra, M. F. Coolbaugh, M. A. Ehle, Jr., and C. H. Fulton. 55 pages. 1908.

* *Bulletin No. 9.* The Badland Formations of the Black Hills Region, by C. C. O'Harra. 152 pages. 1910. See also Bulletin No. 13.

* *Bulletin No. 10.* The Minerals of the Black Hills, by Victor Ziegler. 200 pages. 1914.

Bulletin No. 11. A Bibliography of the Geology and Mining Interests of the Black Hills Region, by C. C. O'Harra. 225 pages. 1917.

* *Bulletin No. 12.* The Occurrence, Chemistry, Metallurgy and Uses of Tungsten with Special Reference to the Black Hills of South Dakota, by J. J. Runner and M. L. Hartmann, including a Bibliography of Tungsten by M. L. Hartmann. 264 pages. 1918.

* *Bulletin No. 13.* The White River Badlands, by C. C. O'Harra. 181 pages and 96 plates. 1920.

Bulletin No. 14. The Geology, Mineralogy, and Scenic Features of Custer State Park, South Dakota, by C. C. O'Harra and J. P. Connolly. 123 pages and 60 plates. 1926. Forty cents and postage.

Bulletin No. 15. The Tertiary Mineralization of the Northern Black Hills, by J. P. Connolly. 130 pages and 19 plates. 1927.

Bulletin No. 16. The Mineral Wealth of the Black Hills, by J. P. Connolly and C. C. O'Harra. 400 pages, 35 figures, 64 plates. Eighty cents plus postage.

Note: A map of the Black Hills Region has also been published.

TENNESSEE

VANDERBILT UNIVERSITY, Nashville. James H. Kirkland, Chancellor; W. H. Schuerman, Dean of the School of Engineering.

No engineering research organization.

No engineering research reported.

TEXAS

THE RICE INSTITUTE, Houston. Edgar Odell Lovett, President; L. B. Ryon, Professor of Civil Engineering; H. K. Humphrey, Professor of Electrical Engineering; J. H. Pound, Professor of Mechanical Engineering.

No engineering research organization.

Channels of Publication: Proceedings of societies and the technical press.

Live Research Projects

1. Slip Meters: (a) Rolling Ball and (b) Magneto. J. S. Waters and H. K. Humphrey.
2. Certain Methods of 3-Phase Calculations. H. K. Humphrey.
3. Friction Loss Across Welded Bends and Tube Turns. J. H. Pound.

TEXAS TECHNOLOGICAL COLLEGE, Lubbock. P. W. Horn, President; William J. Miller, Dean of the School of Engineering.

* Out of print.

No engineering research organization.

Employees for 1929–30: Part time, 2, estimated equivalent to ⅓ full time.

No projects or publications reported.

UNIVERSITY OF TEXAS, Austin. H. Y. Benedict, President; T. U. Taylor, Dean of the College of Engineering; S. P. Finch, Director of the Bureau of Engineering Research.

Engineering Research Organization: Bureau of Engineering Research, created by the Board of Regents in 1915 as the Engineering Division of the Bureau of Economic Geology and Technology.

Funds Available for 1929–30: Allotment by University authorities, $7,850; due to materials testing and automobile headlight testing done for the State Highway Department only a small part of this fund is available for research.

Employees for 1929–30: Full time, 2; part time, 2. In addition, several members of the faculty are engaged in research work assisted by the Bureau's funds.

Channel of Publication: Bulletins of the University of Texas.

Engineering Research Bulletins Published

Bulletin No. 16. Rice Irrigation in Texas, by T. U. Taylor. 1902.

Bulletin No. 164. The Austin Dam, by T. U. Taylor. 1910.

Bulletin No. 189. The Composition of Coal and Lignite and the Use of Producer Gas in Texas, by W. B. Phillips, S. H. Worrell, and D. M. Phillips. 1911.

Bulletin No. 362. Methods of Sewage Disposal for Texas Cities, by R. M. Jameson. 1914.

Bulletin No. 1. Annual Flow and Run-Off of Some Texas Streams, by T. U. Taylor. 1915.

Bulletin No. 26. Street Paving in Texas, by E. T. Paxton. 1915.

Bulletin No. 62. Road Materials of Texas, by J. P. Nash. 1915.

Bulletin No. 65. Run-Off and Mean Flow of Some Texas Streams, by T. U. Taylor. 1915.

Bulletin No. 1725. Texas Granites, by J. P. Nash. 1917.

Bulletin No. 1733. Papers on Water Supply and Sanitation, by R. G. Tyler, Editor. 1917.

Bulletin No. 1735. Papers on Roads and Pavements, by R. G. Tyler, Editor. 1917.

Bulletin No. 1752. Boiler Waters: Their Chemical Composition, Use, and Treatment, by W. T. Read. 1917.

Bulletin No. 1759. The Friction of Water in Pipes and Fittings, by F. E. Giesecke. 1917.

Bulletin No. 1771. Tests of Concrete Aggregates Used in Texas, by J. P. Nash. 1917.

Bulletin No. 1814. Chemical Analyses of Texas Rocks and Minerals, by E. P. Schoch. 1918.

Bulletin No. 1815. Physical Properties of Dense Concrete as Determined by the Relative Quantity of Cement, by F. E. Giesecke and S. P. Finch. 1918.

Bulletin No. 1839. Road Building Materials in Texas, by J. P. Nash, in cooperation with C. L. Baker, E. L. Porch, and R. G. Tyler. 1918.

Bulletin No. 1855. The Strength of Fine-Aggregate Concrete, by F. E. Giesecke, H. R. Thomas, and G. A. Parkinson. 1918.

Bulletin No. 1922. Papers on Pavements Presented at Engineering Short Course, by R. G. Tyler. 1919.

Bulletin No. 2215. Progress Report of the Engineering Research Division of the Bureau of Economic Geology and Technology, by F. E. Giesecke, H. R. Thomas, and G. A. Parkinson. 1922.

Bulletin No. 2439. Silting of the Lake at Austin, Texas, by T. U. Taylor. 1924.

Bulletin No. 2712. The Friction of Water in Elbows, by F. E. Giesecke, C. P. Reming, and J. W. Knudson. 1927.

Bulletin No. 2730. Effect of Various Salts in the Mixing Water on the Compressive Strength of Mortars, by F. E. Giesecke, H. R. Thomas, and G. A. Parkinson. 1927.

*Bulletin No. 2813.** Testing of Motor Vehicle Headlighting Devices and Investigation of Certain Phases of the Headlight Glare Problem, by C. R. Granberry. 1928.

Bulletin No. 2814. Effect of Physical Properties of Stone Used as Coarse Aggregate on the Wear and Compressive Strength of Concrete, by H. R. Thomas and G. A. Parkinson. 1928.

Bulletin No. 2825. Preliminary Report on Relation between Strength of Portland Cement Mortar and Its Temperature at Time of Test, by G. A. Parkinson, S. P. Finch, and J. E. Hoff. 1928.

Bulletin No. 2922. A Study of Tests of Cylinders and Cores Taken from Concrete Roads in Texas during 1928, by John A. Focht. 1929.

Live Research Projects

1. An Investigation of Shaded Magnetic Circuits. J. P. Woods and J. A. Correll.

2. A Study of Variation in Daylight Intensities. C. R. Granberry and J. P. Woods.

3. Heat Transfer Coefficient Determination for Various Fluids. B. E. Short.

4. Relation between Strength of Portland Cement Mortar and Its Temperature at Time of Test. A continuation of work summarized in Bulletin No. 2825. R. F. Dawson, G. A. Parkinson, and S. P. Finch.

UTAH

UNIVERSITY OF UTAH, Salt Lake City. George Thomas, President; R. B. Ketchum, Dean of the School of Mines and Engineering; D. A. Lyon, Director of the Engineering Experiment Station.

Engineering Research Organization: Utah Engineering Experiment Station, created by the legislature, 1909.

Funds Available for 1929–30: Direct appropriation by the legislature, $28,450; allotment by University authorities, $20,000; grants from other sources, $9,245.

Channels of Publication: Bulletins, technical papers, circulars of information, and reports of investigations.

* By error printed as Bulletin No. 2831.

Technical Papers and Bulletins Published

Mining and Metallurgical Investigations under the auspices of The U. S. Bureau of Mines, The Department of Mining and Metallurgical Investigations of the Utah Engineering Experiment Station and The Advisory Board.

* *Technical Paper No. 1.* Flotation Fundamentals, Part 1.

* *Technical Paper No. 2.* Preparation of Xanthates and Other Organic Thiocarbonates.

Technical Paper No. 3. A Consideration of Some of the Problems of the Chloride Volatilization Process. Fifteen cents.

Technical Paper No. 4. Flotation Fundamentals, Part 2. Flotation of Chalcocite. Twenty-five cents.

Technical Paper No. 5. Flotation Fundamentals, Part 3. Flotation of the Carbonates of Copper: Malachite and Azurite. Thirty-five cents.

Technical Paper No. 6. Study of the Roasting of Zinc Ores as a Preparation for Hydrometallurgical Treatment. Twenty-five cents.

Technical Paper No. 7. Flotation Fundamentals, Part 4, by Gaudin, Haynes, and Haas. (Has been approved by Washington Office for publication.)

Technical Paper No. 8. The Technique of Preparing Thin Rock Sections. Seventy-five cents.

Technical Paper No. 9. Flotation Fundamentals, Part 5, by Gaudin and Anderson. (Has been submitted to Washington Office for approval for publication.)

Technical Paper No. 10. A New Development in the Preparation of Briquetted Mineral Grains, by Head and Slavin. (Has been submitted to Washington Office for approval for publication.)

Technical Paper No. 11. The Beneficiation of a Manganese Ore by the Volatilization of Objectionable Impurities. (Ready to be submitted to Washington Office for approval for publication).

Technical Paper No. 12. A Method for the Determination of Cadmium in Mill and Smelter Products. (Ready to be submitted to Washington Office for approval for publication.)

Technical Paper No. 13. Reduction of Zinc Ferrite, by Oldright and Hultgren. (In preparation for publication.)

Technical Paper No. 14. Recovery of Potash from Porphyritic Copper Gangue, by Oldright, Keck, et al. (In preparation for publication.)

Technical Paper No. 15. A Cheap Process for the Manufacture of Calcium Chloride, by Oldright et al. (In preparation for publication.)

** *Technical Paper No. 16.* Flotation Fundamentals, Part 6. The Separation of Sphalerite from Pyrite and Pyrrhotite. (In preparation for publication.)

** *Technical Paper No. 17.* Flotation Fundamentals, Part 7. The Separation of Feldspar from Mica and Quartz. (In preparation for publication.)

** *Technical Paper No. 18.* Flotation Fundamentals, Part 8. The Flotability of Chalcopyrite. (In preparation for publication.)

** *Technical Paper No. 19.* Flotation Fundamentals, Part 9. Some Flotation Studies on the Jarosites. (In preparation for publication.)

** *Technical Paper No. 20.* The Beneficiation of Zinc Concentrates by the Volatilization and Removal of Some Component Parts. (In preparation for publication.)

Bulletin No. 14. Research Investigations, 1922–1923. Hydrometallurgy of Zinc. Flotation Experiments on Utah Sulphur Ore, Oil Shale Investigations, Zinc Oxide Investigations. Free.

* Out of print.

** To be published during the fiscal year 1930–1931. Based on theses of fellowship men during the year 1929–1930.

Bulletin No. 15. Research Investigations, 1923–1924. Hydrometallurgy of Zinc, Investigations on Utah Hydrocarbons, Ore Deposits of Promontory Point District, Complex Ores of Park City District. Free.

Bulletin No. 16. Research Investigations, 1924–1925. Hydrometallurgy of Lead, Investigations on Utah Hydrocarbons, Flotation Fundamentals and Their Application, Surface Measurements on Finely Ground Particles. Free.

Bulletin No. 17. Research Investigations, 1925–1926. Reduction Treatment of Lead Blast Furnace Charge, Flotative Properties of Common Gangue Minerals, Roasting Zinciferous Sulphide Ores. Free.

Live Research Problems

Problem No. SL-1. Microscopic Investigations of the Various Phases of the Complex Ore Problem.

Problem No. SL-1a. Study of Minus 200 Mesh Products of Elutriation in Relation to Flotation Losses.

Problem No. SL-2a. Separation of Impurities from Zinc Concentrates by Volatilization.

Problem No. SL-3a. Measuring the Work Done in Crushing and Grinding.

Problem No. SL-5. Flotation Fundamentals.

Problem No. SL-5a2. Flotation of Chalcopyrite.

Problem No. SL-5b2. Flotation of Carbonates and Silicates of Copper.

Problem No. SL-5d. Effect of Grain Size on Differential Flotation.

Problem No. SL-5e1. Flotation of Carbonates and Sulphates of Lead.

Problem No. SL-5f1. Flotation of Sphalerite.

Problem No. SL-5f2. The Separation of Sphalerite from Pyrite and Pyrrhotite.

Problem No. SL-5g1. Selective Flotation of Feldspar and Mica from Quartz.

Problem No. SL-5h1. Is Oxidation Catalysis the Basis of Operation of Collectors for Sulfide Minerals?

Problem No. SL-5i. Flotation of Jarosites.

Problem No. SL-6. Study of the Roasting of Zinc Ores as a Preparation for Hydrometallurgical Treatment to Secure Maximum Solubility of Zinc.

Problem No. SL-8a. A Study of the Forms in Which Lead is Now Being Lost in Smelter Slags. (Examination of smelter, Kellogg, Idaho.)

Problem No. SL-9. The Manufacture of Calcium Chloride Cheaply to be Used as a Reagent to Prevent Losses of Lead in Brine Leaching of Lead Ores and in the Production of Potash from Mill Tailings.

Problem No. SL-10. Miscellaneous.

Problem No. SL-12. Recovery of Potash from Tailings of Porphyry Copper Properties.

Problem No. SL-14. Geophysical Prospecting—the Relationship between Electrical Conductivity and the Frequency of the E.M.F.

Problem No. SL-15. Utilization of Alunite as a Source of Potash and Metallic Aluminum.

Problem No. SL-16. The Crystal Structure of Minerals and Intermediate Metallurgical Products as a Guide to the Improvement of Ore Dressing and Metallurgical Processes.

VIRGINIA

VIRGINIA MILITARY INSTITUTE, Lexington. William H. Cocke, Superintendent; James A. Anderson, Professor of Civil Engineering; Stewart W. Anderson, Professor of Electrical Engineering.

No engineering research organization.

No engineering research reported.

WASHINGTON AND LEE UNIVERSITY, Lexington. Francis P. Gaines, President; James Lewis Howe, Dean of the School of Applied Science.

No engineering research organization.

No engineering research reported.

WASHINGTON

UNIVERSITY OF WASHINGTON, Seattle. Matthew Lyle Spencer, President; Richard G. Tyler, Dean of the College of Engineering; C. E. Magnusson, Director of the Engineering Experiment Station.

Engineering Research Organization: Engineering Experiment Station, created by the Board of Regents, 1917.

Funds Available for 1929–1930: Allotment by University authorities, $4,500.

Employees for 1929–1930: Several members of the faculty have a research time allowance equivalent to from 2 to 5 hours teaching credit.

Channels of Publication: Station Bulletins and Reports.

Engineering Experiment Station Bulletins and Reports Published

* *Bulletin No. 1.* Creosoted Wood Stave Pipe and Its Effect upon Water for Domestic and Irrigational Uses. 1917. (Bureau of Industrial Research.) 20 pp.

* *Bulletin No. 2.* An Investigation of the Iron Ore Resources of the Northwest, by William Harrison Whittier. 1917. (Bureau of Industrial Research.) 128 pp.

* *Bulletin No. 3.* An Industrial Survey of Seattle, by Curtis C. Aller. 1918. (Bureau of Industrial Research.) 64 pp.

* *Bulletin No. 4.* A Summary of Mining and Metalliferous Mineral Resources in the State of Washington with Bibliography, by Arthur Homer Fischer. 1919. 124 pp. and one 18″ x 26″ map.

Bulletin No. 5. Electrometallurgical and Electrochemical Industry in the State of Washington, by Charles Denham Grier. 1919. 43 pp. Fifty cents.

* *Bulletin No. 6.* Ornamental Concrete Lamp Posts, by Carl Edward Magnusson. 1919. 24 pp.

Bulletin No. 7. Multiplex Radio Telegraphy and Telephony, by F. M. Ryan, J. R. Tolmie, and R. O. Bach. 1920. 24 pp. Fifty cents.

Bulletin No. 8. Voltage Wave Analysis with Indicating Instruments, by Leslie Forrest Curtis. 1920. 28 pp. Fifty cents.

* *Bulletin No. 9.* The Coking Industry of the Pacific Northwest, by Joseph Daniels. 1920. 36 pp.

Bulletin No. 10. An Investigation of Compressed Spruce Pulleys, by George Samuel Wilson. 1920. 72 pp. Eighty cents.

Bulletin No. 11. The Theory of Linear-Sinoidal Oscillations, by Henry Godfrey Cordes. 1920. 24 pp. Forty cents.

Bulletin No. 12. Motor Truck Logging Methods, by Frederick Malcolm Knapp. 1921. 52 pp. Fifty cents.

Bulletin No. 13. Tensions in Track Cables and Logging Skylines, by Samuel Herbert Anderson. 1921. 28 pp. Thirty-five cents.

* Out of print.

Bulletin No. 14. Current Suppression by Means of Parallel Resonance, by Henry Godfrey Cordes. 1921. 15 pp. Twenty-five cents.

Bulletin No. 15. Electric Heating of Residences. Part I, by Edgar Allan Loew. 1921. 44 pp. Fifty cents.

Bulletin No. 16. Sewage Disposal for Suburban Homes and for Isolated Institutions, by William Franklin Allison. 1922. 38 pp. Thirty-five cents.

Bulletin No. 17. Transmission Line Design. Part I, Mechanical Features. Section A: Design of Spans with Supports at Equal Elevation, by Frederick Kurt Kirsten. 1923. 110 pp. and two 20″ x 20″ charts. One dollar.

* *Bulletin No. 18.* The Clays and Shales of Washington, by Hewitt Wilson. 1923. 224 pp.

* *Bulletin No. 19.* The Chemical Utilisation of Wood in Washington, by Henry Kreitzer Benson, Thomas Gordon Thompson and George Samuel Wilson. 1923. 160 pp.

Bulletin No. 20. Electric Heating of Residences. Part II, by Edgar Allan Loew. 1923. 48 pp. Fifty cents.

Bulletin No. 21. Experimental Data on Relative Cost of Gas and Electricity for Cooking, by Martha Estella Dresslar. 1923. 16 pp. Twenty-five cents.

Bulletin No. 22. An Analysis of the Weir Coefficient for Suppressed Weirs, by Charles William Harris. 1923. 26 pp. Thirty-five cents.

Bulletin No. 23. The Electrostatic Electromagnetic Conversion Factor, by Loyal Vivian Bewley. 1924. 25 pp. Twenty-five cents.

Bulletin No. 24. Characteristic Surfaces of Thermionic Valves, by Jack Roderick Tolmie. 1924. 28 pp. Thirty-five cents.

Bulletin No. 25. Development of Influence Lines as Applied to Statically Indeterminate Airplane Beams, by Robert James Minshall and Frederick Burt Farquharson. 1924. 20 pp. Thirty-five cents.

Bulletin No. 26. Hydro-Electric Power in Washington. Part I, A Reconnaissance Survey, by Carl Edward Magnusson. 1924. 52 pp. and nine 7″ x 10″ plates. Fifty cents.

Bulletin No. 27. A Comparative Test of the Flow of Water in 8″ Concrete and Vitrified Clay Sewer Pipe, by Elgin Roscoe Wilcox. 1924. 48 pp. Fifty cents.

Bulletin No. 28. Coal Washing Problems of the Pacific Northwest, by Earl Renwick McMillan and Byron Matthew Bird. 1924. 240 pp. Two dollars.

Bulletin No. 29. Transmission Line Design. Part 1, Mechanical Features. Section B: Design of Spans with Supports at Unequal Elevation, by George Sherman Smith. 1924. 48 pp. Fifty cents.

Bulletin No. 30. Oscillograph Determinations of the Triode Static Characteristics, by Albert Kalin. 1925. 32 pp. Thirty-five cents.

* *Bulletin No. 31.* Lowering the Cost of Concrete in the Pacific Northwest, by Ira Leonard Collier. 1925. 32 pp.

Bulletin No. 32. Transmission Line Design. Part 2, Electrical Features. The Line of Maximum Economy, by Frederick Kurt Kirsten and Edgar Allan Loew. 1925. 152 pp. and four 7″ x 13″ plates. One dollar and fifty cents.

Bulletin No. 33. Intakes for High Velocity Flumes, by Charles William Harris and James Baker Hamilton. 1925. 27 pp. Twenty-five cents.

Bulletin No. 34. Centrifugal Fans: Performance Characteristics and Methods of Testing, by George Samuel Wilson, William Lyle Dudley, and Harry John McIntyre. 1926. 38 pp. Thirty cents.

Bulletin No. 35. Pressure Reduction on the Face of Orifice Plates and Weirs, by Charles William Harris. 1926. 27 pp. Twenty-five cents.

* Out of print.

Bulletin No. 36. Hydroelectric Power in Washington. Part 2, A Bibliography of Technical Papers, by Carl Edward Magnusson. 1926. 143 pp. Seventy-five cents.

Bulletin No. 37. Combined Concrete and Timber in Flexure, by George Danforth Burr. 1926. 22 pp. Twenty-five cents.

Bulletin No. 38. The Wind Balance in the Boeing Aerodynamical Laboratory at the University of Washington, by Frederick Burt Farquharson. 1926. 23 pp. Twenty-five cents.

Bulletin No. 39. Cost Estimate of Irrigation Work, by Robert Bowman Van Horn. 1926. 63 pp. Fifty cents.

Bulletin No. 40. The Oscillograph in Electric Transients, by George Sherman Smith. 1927. 61 pp. Fifty cents.

Bulletin No. 41. Salinity of the Lake Washington Ship Canal. Study of the Conditions Affecting the Flow of Sea Water in the Canal System, by Eli Victor Smith and Thomas Gordon Thompson. 1927. 104 pp. One dollar.

Bulletin No. 42. Tests and Theory of Curved Beams, by Arthur Melvin Winslow and Robert Harold Gray Edmonds. 1927. 25 pp. Twenty-five cents.

Bulletin No. 43. A Comparison of the Effect of High Temperatures on Concretes of High Alumina and Ordinary Portland Cements, by Alfred Lawrence Miller and Herbert Franklin Faulkner. 1927. 24 pp. Twenty-five cents.

Bulletin No. 44. Transmission Line Design. Part 3, A 500-Mile Transmission Line, by Frederick Kurt Kirsten and Clifford Milton Briggs. 1927. Ninety cents.

Bulletin No. 45. Loss of Head in Three Types of Water Meters, by Charles William Harris. 1927. 30 pp. Thirty cents.

Bulletin No. 46. The Float-and-Sink Testing of Fine-Size Coal, by Byron Matthew Bird and Harold Eli Messmore. 1928. 36 pp. Thirty-five cents.

Bulletin No. 47. Strength Tests on Solid and Laminated Douglas Fir Cross Arms, by Bror Leonard Grondal. 1928. 31 pp. Thirty cents.

Bulletin No. 48. The Influence of Pipe Thickness on Re-Entrant Intake Losses, by Charles William Harris. 1928. 35 pp. Thirty-five cents.

Bulletin No. 49. Radiography of Light Metal Alloys, by S. Herbert Anderson and Louis Marick. 1928. 21 pp. Twenty-five cents.

Bulletin No. 50. Transmission Line Design. Part 4, Choice of Line Voltage and Conductor Size, by Edgar Allan Loew. 1929. 27 pp. Thirty cents.

Bulletin No. 51. The Suppression of Intake Losses by Various Degrees of Rounding, by James Baker Hamilton. 1929. 36 pp. Thirty-five cents.

Bulletin No. 52. Kilovolt-Ampere-Hour Meters, by Gordon Russell Shuck. 1930. 38 pp. Forty cents.

Bulletin No. 53. The Four Element Tube as an Audio Amplifier, by Austin Vitruvius Eastman. 1930. 30 pp. Thirty-five cents.

Bulletin No. 54. Elimination of Hydraulic Eddy Current Loss at Intake, by Charles William Harris. In press.

Report No. 1. The Pulp and Paper Industry of the Pacific Northwest, by Henry Kreitzer Benson. 1929. 89 pp. Seventy-five cents.

Report No. 2. Iron and Steel Manufacture in Washington, Oregon, California, and Utah, by Joseph Daniels. 1929. 69 pp. Sixty-five cents.

WISCONSIN

SCHOOL OF ENGINEERING OF MILWAUKEE, Milwaukee. Oscar Werwath, President; John D. Ball, Vice-President and Educational Director.

No engineering research organization. A little research work reported in connection with thesis and occasionally on the part of a faculty member.

IN CANADA

ALBERTA

UNIVERSITY OF ALBERTA, Edmonton. Robert C. Wallace, President; R. S. L. Wilson, Dean of the Faculty of Applied Science; Robert C. Wallace, Director of the Research Council of Alberta.

Engineering Research Organization: Research Council of Alberta, created by the legislature in 1920 and reorganized in 1930; operating within the University but separate as to finances and in a considerable measure as to staff.

Funds Available for 1929–1930: Direct appropriation by legislature, $38,725.00; natural resources vote by legislature, $44,152.50; from National Research Council (Canada), $5,200.00.

Employees for 1929–1930: Full time, 14; part time, 7, estimated equivalent to 3 full time.

Channels of Publication: Research Council of Alberta Reports, Bulletins, and Circulars, and articles in the technical press.

Publications of the Research Council of Alberta

Annual Reports of Council

No. 3. (For calendar year 1920); pp. 36. Five cents.
No. 5. (For calendar year 1921); pp. 86. Thirty-five cents.
No. 8. (For calendar year 1922); pp. 64. Thirty-five cents.
No. 10. (For calendar year 1923) with 4-color map of Alberta coal areas; pp. 76. Fifty cents. Map No. 6 only, fifteen cents.
No. 12. (For calendar year 1924); pp. 66. Thirty-five cents.
No. 16. (For calendar year 1925); pp. 65. Thirty-five cents.
No. 20. (For calendar year 1926); pp. 53. Twenty-five cents.
No. 22. (For calendar year 1927); pp. 49. Twenty-five cents.
No. 24. (For calendar year 1928); pp. 53. Reviews the work done during 1928 under the auspices of the Research Council. Results are reported with respect to slacking characteristics, fusibility of ash, and other special tests on coal, together with continuation of the work on briquetting of coal. A geological report is given of the Jasper Park district, and some preliminary notes on the geology of the Peace Hills area and the Athabaska and Lesser Slave Lake districts. Further work on asphalt emulsions for highway surfacing and the formation of emulsion during bituminous sand separation operations is outlined, and other laboratory studies of the bituminous sand separation process are discussed. Short reports are also given on soil survey of the district adjacent to Lesser Slave Lake, and on researches undertaken on the chemical utilization of the natural gas of Alberta. Thirty-five cents.

Reports—Fuels

No. 10A. Combustion of Coal for the Generation of Power, by C. A. Robb. 1923. Multigraphed copies only. Fifty cents.
No. 14. Analyses of Alberta Coals, with 18 maps and 2 charts, by E. Stansfield, R. T. Hollies, and W. P. Campbell. 1925; pp. 64. Twenty-five cents.

Reports—Road Materials

No. 18. The Bituminous Sands of Alberta, by K. A. Clark and S. M. Blair.
Part I. Occurrence, pp. 74. Twenty-five cents.
Part II. Separation, pp. 36. Twenty-five cents.
Part III. Utilization, pp. 33. Twenty-five cents.

Reports—Geological Survey Division

No. 1. A Summary of Information with Regard to the Mineral Resources of Alberta, by J. A. Allan. 1919; pp. 104.

No. 2. Supplements the information contained in Report No. 1. 1920; pp. 138 + 14.

No. 4. Geology of the Drumheller Coal Field, Alberta. 1921; pp. 72 and 6-color map (Serial No. 1). One dollar.

* *No. 6.* Geology of the Saunders Creek and Nordegg Coal Basins, Alberta, by J. A. Allan and R. L. Rutherford. 1922, Part I; pp. 76 and 2-color map (Serial No. 2).

No. 7. An Occurrence of Iron on the North Shore of Lake Athabaska, by J. A. Allan and A. E. Cameron. 1922, Part II; pp. 40; two maps (Serial Nos. 3 and 4). Twenty-five cents.

No. 9. Geology along Blackstone, Brazeau and Pembina Rivers in the Foothills Belt, Alberta, by J. A. Allan and R. L. Rutherford. 1923; pp. 48 and 6-color map (Serial No. 5). Continuation of the field work in the area described in Report No. 6. Seventy-five cents.

No. 11. Geology of the Foothills Belt between McLeod and Athabaska Rivers, Alberta, by R. L. Rutherford. 1924; pp. 61 and 8-color map (Serial No. 7). One inch to two miles. Continuation of the area described in Report No. 9. Seventy-five cents.

No. 13. Geology of Red Deer and Rosebud Sheets, by J. A. Allan and J. O. G. Sanderson. Two geological maps in 8 colors. Scale, one inch to three miles. Serial No. 8 Red Deer Sheet and No. 9 Rosebud Sheet. Five structure sections. (Report in preparation.)

Map No. 10. Geological Map of Alberta, by J. A. Allan. 1925; in 14 colors. Scale, one inch to 25 miles.

No. 15. Geology of the Area between Athabaska and Embarras Rivers, Alberta, by R. L. Rutherford. Pp. 29 and 3-color map (Serial No. 11). One inch to two miles. Eastward extension of field survey described in Report No. 11. Fifty cents.

No. 17. Geology along Bow River between Cochrane and Kananaskis, Alberta, by R. L. Rutherford. Pp. 46 and 9-color map (Serial No. 12). Scale, one inch to one mile. One dollar, or map alone fifty cents.

No. 19. Geology of the Area between North Saskatchewan and McLeod Rivers, Alberta, by R. L. Rutherford. Pp. 37 and 3-color map (Serial No. 13). Scale, one inch to three miles. Fifty cents.

Live Research Projects

1. Geological Survey Work in the Province of Alberta.
2. Bituminous Sands Investigations.
3. Use of Electric Power on Farms.
4. Extensive Investigations and Researches in Coal.
5. Natural Gas Utilization.
6. Soil Surveys.

* Out of print.

All the above are described in the annual reports of the Alberta Research Council.

7. Power Losses in Dielectrics. H. J. McLeod.

8. Influence of Low Atmospheric Temperatures on Mechanical Properties of Metals. A. E. Cameron and I. F. Morrison.

New Brunswick

University of New Brunswick, Fredericton. Cecil Charles Jones, President; John Stephens, Dean of Applied Science.

No engineering research organization.

Engineering research reported as incidental only.

Ontario

Queen's University, Kingston. R. Bruce Taylor, Principal; A. L. Clark, Dean of the Faculty of Applied Science.

No engineering research organization. Engineering research is carried on like any other research work. No distinction is made. About $10,000 total is spent.

Royal Military College, Kingston. W. H. Elkins, Commandant; E. J. Schmidlin, Dean of Engineering.

No engineering research.

University of Toronto, Toronto. Sir Robert Falconer, President; Brig. Gen. C. H. Mitchell, Dean of the Faculty of Applied Science and Engineering; M. C. Boswell, Secretary of the School of Engineering Research.

Engineering Research Organization: School of Engineering Research, created by the Board of Governors, 1911.

Funds Available for 1929–1930: Allotment by University authorities, $22,300.

Employees for 1929–1930: Full time, 3; part time, 22.

Channels of Publication: Technical and scientific journals and Bulletin of the School of Engineering Research.

School of Engineering Research Bulletins Published

The bulletins are issued complete, and also in sections containing the individual papers. No charge is made for the bulletins or sections.

Bulletin No. 1 *

The School of Engineering Research, by Maitland C. Boswell.

The Investigation of Girderless Concrete Floors, by Peter Gillespie and T. D. Myhea.

An Improvised Vibrometer, by G. R. Anderson.

Preliminary Report on an Investigation into the Concentration of Graphite from Some Ontario Ores, by H. E. T. Haultain, F. C. Dyer, and J. T. King.

* Out of print, including sections.

New and Rapid Apparatus for Electro Chemical Analyses, by J. T. King.

A Research on a 4-Inch Single Stage Turbine Pump, by J. H. Parkin.

The Strength of Cast Iron in Bending as Affected by Variations in Cross Section, by J. H. Billings.

Heat Transfer Tests of Building Materials, by L. M. Arkley.

The Fusion of Sodium Hydroxide with Some Inorganic Salts, by Maitland C. Boswell and J. V. Dickson.

The Action of Sodium Hydroxide on Carbon Monoxide, Sodium Formate and Sodium Oxalate, by Maitland C. Boswell and J. V. Dickson.

The Fusion of Sodium Hydroxide with Several Phenols and Sulphonic Acids, by Maitland C. Boswell and J. V. Dickson.

The Adsorption of Arsenious Acid by Ferric Hydroxide, by Maitland C. Boswell and J. V. Dickson.

The Calculation of Transmission Line Networks, by T. R. Rosebrugh.

The Overload Limitations of High-Voltage Single-Turn-Primary Current Transformers, by W. B. Buchanan.

A Process for Electrolytically Refining Nickel, by G. A. Guess.

BULLETIN No. 2

The Toronto Aerodynamic Laboratory, by J. H. Parkin. Section No. 1.

Alignment of Balance and Model, by J. H. Parkin and H. C. Crane. Section No. 1.

Air Speed Indicators for Wind Channel, by J. H. Parkin. Section No. 1.

Studies with a Full Scale Four Foot N.P.L. Type Wind Channel of the Proper Form of Intake to Eliminate Disturbances, by J. H. Parkin and H. C. Crane. Section No. 1.

Wind Tip Research, by J. H. Parkin, H. C. Crane, and S. L. Galbraith. Section No. 1.

Balance Portion for the Rudder of the F. 3 Flying Boat, by J. H. Parkin, H. C. Crane, and S. L. Galbraith. Section No. 1.

Macdonald Aerofoils, by J. H. Parkin, H. C. Crane, and S. L. Galbraith. Section No. 1.

Rudder Balance for F. 3 Flying Boat, by J. H. Parkin, E. V. Ahara, and J. S. E. MacAllister. Section No. 1.

The Bellis and Morcom Spring Governor, by J. H. Parkin. Section No. 2.

The Imhoff Sewage Tank in America: A Decade of Operation Reviewed, by Peter Gillespie. Section No. 3.

Effects of Magnetic Leakage in Current Transformers, by H. W. Price and C. K. Duff. Section No. 4.

Method of Measuring Ratio and Phase Angle, by H. W. Price and C. K. Duff. Section No. 4.

Through-Type Portable Current Transformers, by H. W. Price and C. K. Duff. Section No. 4.

Determination of Turn-Ratio of Current Transformers, by C. K. Duff. Section No. 4.

Minimizing the Errors of Current Transformers by Means of Shunts, by H. W. Price and C. K. Duff. Section No. 4.

True Net Sections of Riveted Tension Members, by C. R. Young. Section No. 5.

Investigation of the Proportioning of Concrete Mixtures, by Peter Gillespie and A. R. Duff. Section No. 6.

BULLETIN No. 3

The Constitution of Rubber, by Maitland C. Boswell. Section No. 1.

The Mechanism of the Catalysis of Hydrogenation by Nickel, by Maitland C. Boswell. Section No. 2.

The Preparation of Anhydrous Formic Acid, by Maitland C. Boswell and H. E. Corman. Section No. 3.

The Relative Lowering of Vapour Pressure of Aqueous Solutions, by Maitland C. Boswell and R. C. Cantelo. Section No. 4.

The Determination of Carbon in Graphite, by J. T. King. Section No. 5.

Ball Paths in Tube Mills, by H. E. T. Haultain and F. C. Dyer. Section No. 6.

An Investigation of the Kiln-Drying of Lumber, by Peter Gillespie and A. R. Duff. Section No. 7.

An Investigation of the Opening Up or Loosening of Glue Joints, by A. R. Duff. Section No. 7.

The Drying of Varnish on Furniture, by A. R. Duff. Section No. 7.

A Machine for Making Magnetic Assays, by F. C. Dyer. Section No. 8.

Torsional Strength of Rectangular Sections of Concrete Plain and Reinforced, by C. R. Young, W. L. Sagar, and C. A. Hughes. Section No. 9.

An Attempt to Cheapen the Production of Zirconium Dioxide, by J. W. Bain and George E. Gollop. Section No. 10.

A Study of Heat Efficiency in the Manufacture of Potassium Nitrate, by F. P. Downey and J. W. Bain. Section No. 11.

Wing Tip Research: Part 2, Warped Tips; Part 3, Pin Tips; Part 4, Blade Tips, by J. H. Parkin, H. C. Crane, and J. S. E. MacAllister. Section No. 12.

BULLETIN No. 4

Thick Aerofoils, by J. H. Parkin, H. C. Crane, and J. S. E. MacAllister. Section No. 1.

Downwash, by J. H. Parkin, H. C. Crane, J. S. E. MacAllister, and E. V. Ahara. Section No. 1.

Grooved Aerofoil, by J. H. Parkin, H. C. Crane, and J. S. E. MacAllister. Section No. 1.

End Spindle Corrections in Wind Channel Experiments, by J. H. Parkin, H. C. Crane, J. S. E. MacAllister, and E. V. Ahara. Section No. 1.

Investigation into the Effect of Certain Variations in the Leading Portion of a Thick Aerofoil, by J. H. Parkin, H. C. Crane, and J. S. E. MacAllister. Section No. 1.

Centre of Pressure Determination in Wind Channel Experiments, by J. H. Parkin and H. C. Crane. Section No. 1.

Gunite as a Protection for Steel Structures, by Peter Gillespie and P. J. Culliton. Section No. 2.

Torsional Strength of Steel I-Sections, by C. R. Young and C. A. Hughes. Section No. 3.

A Contribution to the Kick Versus Rittinger Dispute, by H. E. T. Haultain. Section No. 4.

The Determination of Lead as Sulphate, by J. W. Bain and R. I. Wynne-Roberts. Section No. 5.

A Study of Chrome Yellow, by J. Watson Bain. Section No. 6.

The Mechanism of Catalysis by Platinum, by Maitland C. Boswell and R. R. McLaughlin. Section No. 6.

The Assay of Zinc Ores, by E. G. R. Ardagh and G. R. Bongard. Section No. 8.

Simplification of the Separation of Zinc from Iron and Aluminium, by E. G. R. Ardagh and G. R. Bongard. Section No. 9.

An Investigation of Discolouration in Corn Oil Soap and of the Possibility of Preventing its Development, by E. G. R. Ardagh, J. C. Bell, F. S. Spence, and Alex. Murray. Section No. 10.

Certain Useful Forms for the Azimuth Formula, by L. B. Stewart. Section No. 11.

BULLETIN No. 5

The Adjustment and Computation of the Gull Lake Triangulation, by L. B. Stewart. Section No. 1.

Steel I-Beams Haunched in Concrete, by Peter Gillespie and R. C. Leslie. Section No. 2.

Reinforced Concrete Reservoir Walls, by Peter Gillespie and W. B. Dunbar. Section No. 3.

The Effect of Heat upon Cellulose, by J. W. Bain and G. F. Kay. Section No. 4.

The Double Salts Formed by Sodium and Potassium Carbonates, by J. W. Bain. Section No. 5.

An Investigation into the Effect of Constitution on the Malleability of Steel at High Temperatures, by Owen W. Ellis. Section No. 6.

Experiments on the Heat Treatment of Alpha-Beta Brass, by O. W. Ellis and D. A. Schemnitz. Section No. 7.

On the Mechanism of the Inhibition of the Catalytic Action of the Platinum Black and Partially Reduced Nickel Oxide by Chlorine, by M. C. Boswell and C. H. Bayley. Section No. 8.

History of the Renaissance of Architecture in Florence, by K. F. Noxon. Section No. 9.

The Colorimetric Determination of Platinum by Potassium Iodide, by E. G. R. Ardagh, F. S. Seaborne, and N. S. Grant. Section No. 10.

A Simple, Rapid and Economical Method of Separating Nickel and Copper from Iron, by E. G. R. Ardagh and G. M. Broughall. Section No. 11.

BULLETIN No. 6

The Application of Certain Projections to the Construction of General Maps of Canada, by L. B. Stewart. Section No. 1.

Reinforced Concrete Poles, by P. Gillespie and F. E. Wilson. Section No. 2.

Net Sections of Drilled Plates, by C. R. Young and W. B. Dunbar. Section No. 3.

The Effect of Heat upon Cellulose, by J. W. Bain and G. M. Chute. Section No. 4.

An Investigation of Some Properties of Phenylhydrazine and Factors Affecting Hydrazone Formation, by E. G. R. Ardagh and J. G. Williams. Section No. 5.

An Accurate General Iodimetric Method for the Quantitative Determination of the Carbonyl Group in Organic Compounds, by E. G. R. Ardagh and J. G. Williams. Section No. 6.

Distillation of Acetate of Lime, by E. G. R. Ardagh, A. D. Barbour, G. E. McClellan, and E. W. McBride. Section No. 7.

On the Mechanism of the Action of Promoters in Catalysis, by M. C. Boswell and C. H. Bayley. Section No. 8.

On the Mechanism of Catalysis of Aluminium Oxide, by M. C. Boswell and H. M. Dilworth. Section No. 9.

The Influence of Pouring Temperature and Mould Temperature on the Properties of a Lead-Base Anti-Friction Alloy, by O. W. Ellis. Section No. 10.

Intakes for Power Plants, by Robert W. Angus. Section No. 11.

Producer Gas for Road Traction, by E. A. Allcut. Section No. 12.

Some Tests on a Two-Stroke-Cycle Oil Engine, by E. A. Allcut. Section No. 13.

The Influence of Speed on Engine Performance, by E. A. Allcut. Section No. 14.

The Effect of Air on Cupellation Losses, by J. T. King. Section No. 15.

BULLETIN No. 7

The New Aerodynamic Laboratory of the University of Toronto, by J. H. Parkin.

Research on Channel Wall Interference, by J. H. Parkin, J. E. B. Shortt, and C. G. Heard.

Pressure Distribution over U.S.A. 27 Aerofoil with Square Wing Tips, by J. H. Parkin, J. E. B. Shortt, and J. G. Cade.

Pressure Distribution over Gottingen Aerofoil with Square Wing Tips, by J. H. Parkin, J. E. B. Shortt, and J. G. Cade.

Biplane Investigation, by J. H. Parkin, J. E. B. Shortt, and J. G. Cade. Section No. 1.

The Behavior of Cellulose on Heating, by J. W. Bain. Section No. 2.

Coefficients for Venturi Meters and the Effect of an Obstruction in the Throat, by R. W. Angus and J. S. E. MacAllister. Section No. 3.

The Standard Short Tube, by Robert W. Angus. Section No. 4.

The Heat Transfer in Hot Blast Heaters, by Robert W. Angus. Section No. 5.

A Method of Base Line Measurement, by L. B. Stewart. Section No. 6.

Further Tests on a Two-Stroke-Cycle Oil Engine, by E. A. Allcut. Section No. 7.

Charts for Approximate Stress Determination in Reinforced Concrete Chimneys, by P. Gillespie and W. K. Irwin. Section No. 8.

Economic Base Width of Transmission Towers, by C. R. Young, W. B. Dunbar, and C. E. Lewis.

Behavior of Model Transmission Towers under Load, by C. R. Young, W. B. Dunbar, and H. J. A. Chambers.

Effective Length of Bracing Struts in Transmission Towers, by C. R. Young, W. B. Dunbar, and E. B. Allan. Section No. 9.

BULLETIN No. 8

An Investigation of the Draft, Temperature and Combustion Conditions in Commercial Kilns Burning Building Brick, by H. P. Kimbell. Section No. 1.

Report on Pilot Tests Conducted for the Structural Steel Welding at the University of Toronto, 1927–28, by Peter Gillespie, C. A. Hughes, K. B. Jackson, and J. H. Fox. Section No. 2.

Shear Stress in Certain Thin Fillets, by P. Gillespie, C. A. Hughes, K. B. Jackson, and J. H. Fox. Section No. 3.

Effect of Turbulence on the Efficiency of Hot Blast Heaters, by Robert W. Angus. Section No. 4.

Losses in Suction Pipes of Fire Engines, by Robert W. Angus. Section No. 5.

Venturi Meter Coefficients and Friction Loss in a 14-Inch Tee, by Robert W. Angus. Section No. 6.

The Effect of Air Leakage on Turbine Pump Characteristics, by Robert W. Angus and C. V. Armour. Section No. 7.

Orifice Steam Meter Coefficients, by Robert W. Angus. Section No. 8.

Airflow about Wing Tips, by J. H. Parkin, G. J. Klein, and G. L. Roberts.

International Trials, by J. H. Parkin, W. H. Coates, and G. J. Klein.

The Interference between the Body and Wings of Aircraft, by J. H. Parkin and G. J. Klein.

Undercarriage Resistance, by J. H. Parkin, W. H. Coates, and G. J. Klein. Section No. 9.

The Influence of Various Factors on the Power and Economy of a Gasoline Engine, by E. A. Allcut. Section No. 10.

The Uniflow Steam Engine, by E. A. Allcut. Section No. 11.

The System Potassium Carbonate, Sodium Carbonate, and Water at 40° and the Trihydrate of Sodium Carbonate, by J. W. Bain. Section No. 12.

The Elastic Catenary Applied to Base Measurement, by L. B. Stewart. Section No. 13.

A Study of the Determination of Sulphur in Organic Compounds, by E. A. Smith and J. W. Bain. Section No. 14.

A General Theorem on Quantic Determinants, by T. R. Rosebrugh. Section No. 15.

Permissible Stresses on Rivets in Tension, by C. R. Young and W. B. Dunbar. Section No. 16.

A Porous Mediuin for Flotation Cells, by F. C. Dyer and H. L. McClelland. Section No. 17.

Reversed Classification by Crowded Settling, by F. C. Dyer. Section No. 18.

The Chlorination of Methane, by M. C. Boswell and R. R. McLaughlin. Section No. 19.

A Study of Some Factors Influencing Activity of Aluminium and Ferric Chloride in the Friedel and Crafts Reaction, by M. C. Boswell and R. R. McLaughlin. Section No. 20.

The Removal of Thiophene from Benzene and a New Method for the Preparation of Thiophene-Free Benzene on a Laboratory Scale, by E. G. R. Ardagh and C. M. Furber. Section No. 21.

QUEBEC

ECOLE POLYTECHNIQUE DE MONTREAL, Montreal. Aurelien Boyer, Principal; Augustin Frigon, Dean.

No engineering research organization. But little engineering research being done.

MCGILL UNIVERSITY, Montreal. Sir Arthur Currie, Principal. H. M. MacKay, Dean of the Faculty of Applied Science.

Questionnaire reported not suited to conditions in this institution. In order to present the information desired, a tedious amount of explanation and qualification would be required, so that the facts presented should give a reasonably correct picture of the situation. It would also be difficult to tabulate such information in such a way as to give a correct impression.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

TABLE *A*. NON-LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1929–30

State and Institution	Engineering Experiment Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time			
						No.	Equivalent Full Time		
Alabama									
University of Alabama	1907	....	....	....	....	....	....	16[1]	4
California									
Cal. Inst. of Tech.	....[2]	....	....	....	....	....	....	....	27
Saint Mary's College	....	....	....	....	....	....	....	....	....
Univ. of Santa Clara	....	....	....	....	....	....	....	....	....
Univ. of South. Cal.	....	....	....	....	....	5	1	....	5
Stanford University	....	....	Variable amounts from current funds		....	....	....	....	....
Colorado									
University of Colorado	....	....	....	....	....	....	....	....	....
Colorado School of Mines	....[3]	....	$40,000	....	....	....	....	118[4]	....
University of Denver	....	....	2,000	$2,500	....	9	....	....	....
Connecticut									
Yale University	....	....	Not separated		All members engrg. staff			....	46

[1] Includes 14 publications of U. S. Bureau of Mines resulting from studies and experiments conducted at the University of Alabama Station.

[2] Committee on Engineering Research.

[3] Metallurgical and Mining Research Experiment Station.

[4] Colorado School of Mines Quarterly.

[4] Colorado School of Mines Quarterly.

TABLE A. NON-LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1929–30—*Continued*

State and Institution	Engineering Experiment Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time			
						No.	Equivalent Full Time		
District of Columbia									
Catholic Univ. of America	....	....	....	....	....	....	....	....	5
George Washington Univ.	....	....	....	....	....	....	....	....	....
Howard University	....	....	....	....	....	....	....	....	....
Georgia									
University of Georgia	....	....	....	....	....	....	....	1	1
Georgia School of Tech.	....	....	....	....	....	Several		....	....
Illinois									
Armour Inst. of Tech.	....	....	....	....	....	....	....	....	"Many"
Lewis Institute	1916[5]	U. S. Gypsum Co. cooperating			10	....	....	....	....
Northwestern University	....	....	$1,900	....	4	....	....	....	6
Indiana									
Evansville College	....	....	....	....	....	....	....	....	....
University of Notre Dame	....	....	....	....	....	....	....	....	....
Rose Polytechnic Inst.	....	....	....	....	....	....	....	....	....
Tri State College	....	....	....	....	....	....	....	....	....
Valparaiso University	....	....	....	....	....	....	....	....	....
Iowa									
State Univ. of Iowa	....	....	Not separated		....	....	....	1	12
Kansas									
University of Kansas	1907	....	700	....	....	8	2	17	4

[5] Building Materials Research Laboratory.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

TABLE *A*. NON-LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1929–30—*Continued*

State and Institution	Engineering Experiment Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time			
						No.	Equivalent Full Time		
Kentucky									
University of Louisville	....	....	....	....	....	....	....	....	....
Louisiana									
Tulane University	....	....	....	....	....	....	....	....	....
Maryland									
Johns Hopkins Univ.	....	....	....	....	5	13	7	....	17
Massachusetts									
Harvard University	....	....	Not separated		3	Many		49	56
Lowell Textile Inst.	....	....	....	....	....	....	....	13	8
Northeastern Univ.	....	....	....	....	....	....	....	....	....
Tufts College	....	....	$ 5,000	$ 1,000	....	....	....	....	2
Worcester Poly. Inst.	1926[6]	....	....	....	....	4	....	....	....
Michigan									
University of Detroit	....	Considerable testing and investigational work						....	....
College of Min. and Tech.	1927[7]	$50,000	....	....	6	38	13	10	15
University of Michigan	1920[8]	....	26,500	350,000	35	....	....	21	50
Mississippi									
University of Mississippi	....	....	....	....	....	....	....	....	....

[6] Committee on Industrial Research.
[7] Research Committee, composed of heads of departments.
[8] Department of Engineering Research.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

[9] Department of Engineering Research.

TABLE A. NON-LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1929–30—*Continued*

State and Institution	Engineering Experiment Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time			
						No.	Equivalent Full Time		
Missouri									
Washington University	1926[9]	....	....	$2,750	....	3	2	15	7
Montana									
Montana School of Mines	1919[10]	$ 5,000	$8,000	....	5	7	2½	6	18
New Hampshire									
Dartmouth College	....	....	....	....	....	....	....	....	....
New Jersey									
Newark College of Engrg.	....	....	....	....	....	....	....	....	....
Princeton University	....	....	500	....	....	4	1	....	4
Stevens Inst. of Tech.	1929[11]	Faculty members working with industries						....	3
New Mexico									
New Mex. School of Mines	1927[12]	15,000	....	....	1	3	1	4	4
University of New Mexico	....	....	....	....	....	....	....	....	....
New York									
Alfred University	....	....	....	....	....	....	....	....	....
Clarkson College of Tech.	....	....	....	....	....	....	....	....	....
Coll. of the City of N. Y.	....	....	....	....	....	....	....	....	....
Columbia University	....	Research is done in engineering departments						....	....
Cooper Union	....	....	....	....	....	....	....	....	....
Manhattan College	....	....	....	....	....	....	....	....	....
New York University	....	Individuals cooperating with industries					....	....	....

[9] Department of Industrial Engineering and Research.
[10] Bureau of Mines and Geology.
[11] Committee on Research and Industrial Contacts.
[12] State Bureau of Mines and Mineral Resources.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

TABLE A. NON-LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1929–30—*Continued*

State and Institution	Engineering Experiment Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time			
						No.	Equivalent Full Time		
New York—Continued									
Poly. Inst. of Brooklyn	....	Work largely individual			1	6	2	....	1
Rensselaer Poly. Inst.	....	....	$4,500	....	....	....	....	25	70
University of Rochester	....	....	....	....	....	....	....	....	....
Syracuse University	....	....	....	....	....	....	....	....	2
Union College	....	Research by individual professors			....	....	....	....	....
North Carolina									
Duke University	....	....	....	....	....	....	....	....	....
University of N. C.	....	....	500	$ 1,500	....	17	3½	3	14
North Dakota									
University of N. D.	1907[13]	$7,000	1,000	2,800	1	10	7	17	11
Ohio									
University of Akron	....	....	....	....	....	....	....	....	....
Antioch College	1930[14]	....	....	90,000	1	10	4	....	....
Case School of Ap. Sc.	....	....	....	....	....	....	....	....	....
University of Cincinnati	....[15]	....	....	....	....	....	....	....	....
University of Dayton	....	....	....	....	....	....	....	....	....
Ohio Northern Univ.	....	....	....	....	....	....	....	....	....
Ohio University	....	....	....	....	....	....	....	....	....
University of Toledo	....	....	....	....	....	....	....	....	....

[13] Division of Mines and Mining Experiments.
[14] Antioch Industrial Research Institute.
[15] Institute of Scientific Research. Some other research by faculty members.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH

[14] Antioch Industrial Research Institute.
[15] Institute of Scientific Research. Some other research by faculty members.

TABLE A. NON-LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1929–30—*Continued*

State and Institution	Engineering Experiment Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time			
						No.	Equivalent Full Time		
Oklahoma									
University of Oklahoma	....	....	$ 1,500	$ 3,600	....	6	2	....	12
Pennsylvania									
Bucknell University	....	Some small engineering research projects						....	....
Carnegie Inst. of Tech.	1924[16]	....	17,000	1,500	14	9	6	46	16
Gettysburg College	....	....	....	....	....	....	....	....	....
Lafayette College	1921[17]	....	....	2,050	....	5	1	46	9
Univ. of Pennsylvania	....	Each engineering department carries on research							....
Univ. of Pittsburgh	1912[18]	....	....	929,109	209	Numerous		95	72
Swarthmore College	....	....	....	....	....	....	....	....	1
Villanova College	....	....	....	....	....	....	....	....	....
Rhode Island									
Brown University	....	Nearly all professors doing research					....	....	....
South Carolina									
The Citadel	....	....	....	....	....	1	½	....	2
South Dakota									
University of S. D.	....	....	....	....	....	....	....	....	....
State School of Mines	1903[19]	$3,000	....	....	....	....	....	16	....
Tennessee									
Vanderbilt University	....	....	....	....	....	....	....	....	....

[16] Bureau of Metallurgical Research.
[17] Faculty Committee on Research.
[18] Mellon Institute of Industrial Research. Engineering faculty members also do research.
[19] Mining Experiment Station.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

TABLE A. NON-LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1929–30—*Continued*

State and Institution	Engineering Experiment Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time			
						No.	Equivalent Full Time		
Texas									
Rice Institute	....	....	....	....	....	....	....	....	3
Tex. Technological Coll.	....	....	....	....	....	2	½	....	....
University of Texas	1915[20]	....	$ 7,850[21]	....	2	Several		27	4
Utah									
University of Utah	1909	$ 28,450	20,000	$ 9,245	....	....	....	24[22]	22
Virginia									
Virginia Mil. Institute	....	....	....	....	....	....	....	....	....
Washington and Lee Univ.	....	....	....	....	....	....	....	....	....
Washington									
Univ. of Washington	1917	....	4,500	....	....	Several		56	....
Wisconsin									
School of Engineering of Milwaukee	....	A little engineering research			....	....	....	....	....
Totals for Non-Land-Grant Institutions in the United States, 1929–30[23]	22 organizations	$108,450	$141,450	$1,396,054	297	160	55 7/12	626	533

[20] Bureau of Engineering Research.
[21] Includes funds for materials testing and automobile headlight testing.
[22] With the United States Bureau of Mines.
[23] These are totals only for the figures tabulated above, which are obviously incomplete.

[21] Includes funds for materials testing and automobile headlight testing.
[22] With the United States Bureau of Mines.
[23] These are totals only for the figures tabulated above, which are obviously incomplete.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

TABLE *B*. INSTITUTIONS IN CANADA, 1929–30

Province and Institution	Engineering Experiment Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time			
						No.	Equivalent Full Time		
Alberta									
University of Alberta.....	1920[24]	$82,877	....	$5,200	14	7	3	24	8
New Brunswick									
Univ. of New Brunswick....	....	Engineering research incidental only					....	....	....
Ontario									
Queen's University.....	....	....	$10,000	....	....	....	....	....	....
Royal Military Coll.	....	....	....	....	....	....	....	....	....
University of Toronto.....	1911[25]	....	22,300	....	3	22	....	8	....
Quebec									
Ecole Polytechnique.....	....	A little engineering research				....	....	....	....
McGill University.....	....	....	....	....	....	....	....	....	....
Totals for Canada [26].....	2 organizations	$82,877	$32,300	$5,200	17	29	3	32	8

[24] Research Council of Alberta.
[25] School of Engineering Research.
[26] These are totals only for the figures tabulated above, which are obviously incomplete.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

TABLE C. LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1928–29 [27]

State	Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time Paid	Part Time Without Extra Pay		
Alabama	1929	....	....	....	....	....	....	....	....
Arizona	....	....	$10,725	....	2	1	....	14	6
Mines	1915	....	26,898	....	5	7	....	126	4
Arkansas	1920	....	6,600	....	1	....	2	7	4
California	....	....	25,000	....	....	....	....	....	....
Colorado	1917	....	9,000	....	2	2	....	3	6
Connecticut	....	....	....	....	....	....	....	....	....
Delaware	....	....	....	....	....	....	....	....	....
Florida	1929	....	....	....	....	....	8	....	9
Georgia	....	....	7,500	....	1	2	4	....	4
Idaho	1928	....	4,600	....	....	2	3	....	2
Illinois	1903	....	95,505	$132,250	33	21	50	215	81
Indiana	1917	....	33,410	240,000	94	25	6	37	26
Iowa	1904	$57,000	13,200	12,500	10	14	6	97	43
Kansas	1910	....	16,000	44,000	10	45	....	21	34
Kentucky	....	....	....	....	....	....	....	....	....
Louisiana	1925	....	2,500	5,000	....	7	....	4	4

[27] From Engineering Experiment Station Record, Summary, 1929, edited by R. A. Seaton, and published by the Engineering Experiment Station Committee of the Association of Land-Grant Colleges and Universities. Copies can be secured for fifty cents each from Dean Paul Cloke, University of Maine, Orono, Maine.

each from Dean Paul Cloke, University of Maine, Orono, Maine.

TABLE C. LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1928–29—*Continued*

State	Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time Paid	Part Time Without Extra Pay		
Maine	1915	....	$ 5,190	$ 3,200	2	3	2	28	8
Maryland	1921	....	3,500	3,500	....	4	....	....	....
Massachusetts	1919[28]	....	80,500	210,000	50	200	....	317	....
Michigan	1924	....	15,000	7,000	2	3	4	21	12
Minnesota	1921	....	8,750	5,250	2	6	19	10	13
Mines	1911	$33,000	40,000	....	10	....	....	11	2
Mississippi	....	....	....	....	....	....	....	....	....
Missouri	1909	7,500	....	....	....	2	3	28	2
Mines	1909	25,000	....	25,000	11	4	....	42	3
Montana	1924	....	....	....	....	....	1	....	....
Nebraska	1923	....	2,500	....	1	....	3	....	4
Nevada	1921	....	500	....	....	....	4	4	3
New Hampshire	....	....	....	....	....	....	....	....	....
New Jersey	1926	4,490	655	....	....	2	....	2	2
New Mexico	1928	....	....	....	....	....	3	1	1
New York	1923	....	12,900	6,000	6	....	12	10	....
North Carolina	1923	....	9,720	1,200	3	....	10	2	30
North Dakota	....	....	....	....	....	....	....	....	....
Ohio	1913	25,000	20,000	22,500	20	5	22	63	53
Oklahoma	1926	....	....	....	....	....	....	....	11

[28] Division of Industrial Cooperation and Research.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

TABLE C. LAND-GRANT INSTITUTIONS IN THE UNITED STATES, 1928–29—*Continued*

State	Station Established, Year	Funds Available			Employees			Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time Paid	Part Time Without Extra Pay		
Oregon	1927	....	$ 5,000	$ 2,000	....	4	8	2	4
Pennsylvania	1908	....	19,195	1,500	5	6	10	40	13
Rhode Island	....	....	....	....	....	....	....	....	....
South Carolina	1924	....	2,000	....	....	....	5	....	2
South Dakota	1926	....	....	....	....	....	3	....	1
Tennessee	1921	....	1,500	325	....	1	2	8	2
Texas	1914	$ 2,000	4,400	1,800	3	3	10	37	11
Utah	....	....	....	....	....	....	....	....	....
Vermont	1922	....	1,500	....	....	....	....	....	....
Virginia	1921	....	5,155	....	....	3	4	4	19
Washington	1919	....	10,000	7,000	1	4	11	26	17
West Virginia	1921	....	6,000	14,600	1	6	10	4	18
Wisconsin	1914	....	22,500	14,000	3	10	30	79	67
Wyoming	....	....	....	....	....	....	....	....	....
Totals for Land-Grant Institutions of the United States, 1928–29 [29]	39 organizations	$153,990	$527,403	$758,625	278	392	255	1,263	521

[29] These are totals only for figures tabulated above, which are obviously incomplete.

[29] These are totals only for figures tabulated above, which are obviously incomplete.

STATISTICAL SUMMARY OF ENGINEERING RESEARCH AT THE COLLEGES AND UNIVERSITIES OF NORTH AMERICA

TABLE *D*. TOTALS

	Engineering Research Organizations	Funds Available			Employees		Bulletins and Circulars Issued	Live Projects Reported
		Appropriated by Legislature	Allotted by Institution	From Other Sources	Full Time	Part Time		
Totals for Non-Land-Grant Institutions in the United States, 1929–30 [30]	22	$108,450	$141,450	$1,396,054	297	160	626	533
Totals for Land-Grant Institutions in the United States, 1928–29 [30]	39	153,990	527,403	758,625	278	647	1263	521
Totals for United States partly 1928–29 and partly 1929–30 [30]	61	262,440	668,853	2,154,679	575	807	1889	1054
Totals for Canada [30]	2	82,877	32,300	5,200	17	29	32	8
Totals for North America [30]	63	345,317	701,153	2,159,879	592	836	1921	1062

[30] These are totals only for the figures of Tables *A*, *B*, and *C*, which are obviously incomplete.

ENGINEERING RESEARCH SUBJECTS SUGGESTED BY INDUSTRIES

Collected and prepared by H. H. HIGBIE for the Committee on Engineering Research, S. P. E. E.

Since the engineer aims to be useful, it is logical to assume that whenever work of investigation or research is undertaken by students in colleges of engineering it should be directed so that if successful it would possibly and probably be also useful. Some colleges still require theses for the bachelor's degree, while many permit and encourage the student to undertake work of investigation or research, more or less closely supervised in advanced elective courses of instruction. Independent research work is required often for the Master's degree, and always for the doctor's degree which is being valued ever more highly in certain phases of industrial and engineering work. It is probable that a greater number of students could be interested in research work and to a greater degree, if projects were suggested to them as being likely to have significance and value, by people engaged in practical or industrial work rather than by people known to have mainly or only an abstractly scientific interest in the subject. A considerable advantage of such procedure should be the preparation and training which students would thereby receive toward increasing their potential value to some business after graduation, which should make it easier for them to find congenial employment and to succeed in their chosen work.

In pursuance of this idea, about one hundred fifty letters were sent to people who are in charge of research organizations and research departments of industrial concerns. A large majority of the addresses were chosen from Bulletin 60 of the National Research Council entitled "Industrial Research Laboratories of the United States," kindly furnished through the main offices of this Council at the National Academy of Sciences, Washington, D. C. The Bulletin lists about one thousand research laboratories, and the writer attempted to select the largest and best known, if not those believed by him to be doing the most significant work. In the time available to him it was not possible to study carefully the balance among various branches of the engineering profession, but if the initial effort proves sufficiently interesting it may be that the work will be carried further to correct such inadequacies as there may be in this report. About fifty replies have so far been received, thirty-

four of which contain encouragement and suggestions. If the work be not carried on by this Committee on Engineering Research, of the S. P. E. E., anyone desirous of receiving further assistance and advice in matters of engineering research should address himself to Mr. W. Spraragen, Secretary of the National Research Council's Division of Engineering and Industrial Research, who wrote in response to my letter: "We are very much interested in the stimulation of research generally and in particular the bringing of the university research workers together with trade associations and industrialists."

It is not to be expected that everybody, addressed at random with regard to this project to stimulate engineering research in colleges, would be in favor of it. The opposition was a small but significant minority. Some believed that the effort would be fruitless, since it had been tried before without result; these, it seems to the writer, ignore a distinct change in the signs of the times. Others believe that an interest in research that has to be stimulated is too frail to be productive if not to survive; to be consistent these should renounce belief in the efficacy of teaching or training for anything. A few quotations from letters of this minority should prove interesting.

"At various times during the past ten years I have been asked to submit topics for such lists, and thus far have no reason to believe that anyone was led to work on those subjects from the presentation of such lists. The most important factor in any such research is suitable background. If a man is interested in a certain field sufficiently to read and study on that subject, he will soon realize some of the needs for research and can then get in touch with persons qualified to furnish specific details regarding the requirements to be met by the research. On the other hand my editorial experience has convinced me that many of the papers on electro-deposition for example, are of very limited value because the men have not been willing to study the subject or to get a background on which to base the research."

"All of this hullababoo about research is not going to advance the cause materially, because the men who are competent to undertake research will do it anyway; those who are not competent and who are stimulated to attempt some work along this line will probably do nothing more than add to the flood of literature that might as well not have been written."

"I am convinced that in general a purely scientific research cannot be passed from one man to another, except as the teacher does it by personal contact and enthusiastic cooperation. Let me illustrate. Professor Cady, years ago, was interested in Piezo electric phenomena. The very name made most physicists fight

shy of it. I know that it would not have been possible to interest another professor or a distant student in the general subject, and yet Dr. Cady's work, together with that of his students, has been a remarkably good contribution to pure and to engineering science. I could cite many cases of this kind. I once suggested studies of thin films as to electrical conductivity under the influence of X-rays. As a matter of fact no one would ever bother with this experiment, but I cannot complain about that. My main contention is that the professors in the colleges must be depended on more or less completely for the initiative and the interest to carry on with the students, and that usually a suggestion from outside does not 'listen well.'"

Some of the individuals and concerns approached whose business is consultation, investigations and reports, seemed apprehensive that engineering research work in colleges, if stimulated and made to grow, might interfere with their business, particularly if done gratis. Thus, one respondent who is head of a testing laboratory said: "It has always been my conviction that the universities should handle only research work in pure science, leaving the industrial problems for industrial research laboratories. The term 'fundamental research' of course has been injected into the picture in a way that makes it hard to interpret, thus making it difficult to draw any line between what is a function of pure research and industrial development."

"We are working wholeheartedly with your physics department on a well thought out Raman spectrograph bit of research. This is a type of work that you can perform probably better than a research laboratory affiliated with industry. . . . Probably the most important problem of all is, to know more about the electromagnetic waves. We find Hertz and Maxwell intimating many years ago that there seemingly is little difference between light, heat and electricity, other than wave lengths. Maxwell suggested in his day that what we needed most was a method of transforming one wave length into longer or shorter ones. We could do a lot of things if we had such knowledge. In general, I think that the University should handle problems of a pure science nature that add new information which would serve as building blocks for further scientific advance, the look ahead problems and not the immediate ones."

The definite suggestions that were made, of subjects for research, have been arranged in the following part of this report according to the most general classification of fields of work, with the thought that any teacher interested and competent enough to make use of them will desire to make his own detailed classification and file. It was thought also that the nature of the business from which each suggestion emanated would be interesting and useful to know, not

only as furnishing an indication of the complexity of the problems but also as a guide to anyone aspiring to serve a particular industry. The names mentioned are those of the individuals within the organizations who signed the letters in which suggestions were made.

Group A. Power Generation and Distribution. Electrical Apparatus. Radio

The Detroit Edison Company,
2000 Second Ave., Detroit, Michigan,
C. F. Hirshfeld, Chief of Research.

"1. Effect of shape and direction of duct or ducts leading flue gases into suction boxes of induced draft fans. It has been discovered very recently that the performance of the fan may be greatly modified by the direction of the gas stream as it enters the suction box but no data are generally available.

"2. Study of laws controlling flow of air and heating of air in finned radiators of the types now coming into use for concealed radiation. A study of equipment now on the market shows that it has been put together almost or entirely on an empirical basis and that performances vary by several hundred per cent under like conditions.

"3. A study of methods for obtaining average samples of pulverized fuel for fineness test. This should be applicable in operating plants and with respect to both unit mill and central preparation systems.

"4. An investigation of methods of sampling dust carrying gases for the purpose of determining the dust content. We naturally have in mind flue gases from powdered coal plants but the same methods should be applicable in many industries in which material is finely ground.

"5. Carrying of particles in gas currents. There is at present a great lack of authoritative information on the way in which dusts and small particles behave in a current of air or gas. Several researches have been conducted in Europe in connection with air transportation of grain and coal and certain rational formulas have been proposed. The U. S. Bureau of Mines has also done a certain amount of work in connection with the suspension of coal dust in mine atmospheres. I feel that the whole subject might readily form the basis of a series of studies by different men with the object of ultimately producing a complete treatise on the subject. This should cover not only the velocity required to transport particles of different sizes and other characteristics but also the rate of settling, the degree of stratification in horizontal ducts and other items of similar sort.

"6. Resistance to abrasion. The use of powdered fuel has brought to the front our practically complete lack of knowledge regarding what it is that enables materials to resist abrasion. We faced the same problem a long time ago in connection with dredge pumps and found by experience that manganese steel gave reasonably long life. We never determined why this is so, nor have we proved that manganese steel is the best material. Recently we have experimented with different kinds of materials and with different metallic alloys for parts subjected to erosion in powdered fuel preparation and handling plants. Certain materials have proved good in one place and certain other materials in another place. As yet we have no rational explanation of these phenomena. It seems to me that a study in which micro-structure is taken into account in comparison with such other physical characteristics as are usually considered, might throw some light on this subject. The study should cover erosion of different sorts; for example, sharp sand carried by water, sharp sand carried in air blast, and pulverized fuels of different kinds carried in an air blast.

"7. Improved heating and ventilating methods and equipment. In spite of all the work that has been done on the subject of heating and ventilating, we are still far from having reached ideal methods. We also lack certain necessary tests. For example, we have no quantitative methods of measuring odors in occupied rooms. More broadly, we have no real measure of what it is that makes one declare the atmosphere in a given room "stuffy" or otherwise undesirable when compared with out-of-door conditions. It has been suggested that a study of the ionization of indoor as against out-of-door air might possibly throw some light on this subject. There is also much to be done in the determination of the degree to which our present control equipment actually controls. For example, it is conceivable that one could obtain a thermostat which would function within 1° F. or even closer. If this is connected to a steam heating system containing such masses of iron as makes control within 5° F. impossible, it would seem that one should expend his energies in reducing the thermal lag of the heating equipment instead of in attempting to improve the thermostat or its method of controlling the heating equipment.

"8. Heat transfer. The field of heat transfer offers wonderful possibilities. Mr. W. V. A. Kemp, Director of the National Research Council's Committee on Heat Transfer has outlined much of the work that still required doing. Work in this field should be undertaken only with the understanding that one is starting a five to ten year program.

"9. Properties of metals over extended temperature ranges. Our industrial development is driving us to the use of metals at

very high and at very low temperatures. An inspection of existing tabulations of physical data shows great gaps in our knowledge regarding the most fundamental properties. These should be filled as rapidly as possible.

"10. Behavior of metals at elevated temperatures. In a sense this falls within 9 above but it is sufficiently important to be listed separately. We need an almost unlimited amount of experimentation.

"11. Design on the basis of plastic flow. We are already designing on the basis of a permissible percentage creep in an assumed life period. We need a new mechanics of materials to cover design on this new basis for a field in which elastic behavior cannot be assumed.

"12. Behavior of dielectrics. We have gone about as far as we can on the basis of the older knowledge of dielectric phenomena. It is necessary to develop a new science of dielectrics based on the newer physics and newer conceptions of the constitution of matter."

The Edison Electric Illuminating Company of Boston,
39 Boylston St., Boston, Mass.,
H. C. Hamilton, Supt., Standardizing and Testing Dept.

"One of the most important subjects for future consideration is the behavior of electrical insulating materials under stress. A great deal of time is being given at present by the electrical fraternity to the dielectric and much test and research work has been done both in the laboratory and in the field by various commercial organizations to determine the electrical and mechanical characteristics of various insulating materials, both as materials and as parts of finished products such as cables, transformers, etc.

"While the information so obtained has been of great value, I feel that as yet we have only scratched the surface in our study of these materials. For instance, we know practically nothing about the physical and mechanical changes which take place in these materials under stresses of varying magnitudes and of varying durations. We know that under excessive stress dielectrics break down; in other words, a physical and mechanical change takes place in the materials, but we have only a very scant and imperfect picture of the mechanism of break down and of the changes that may take place in the dielectric prior to break down. We do not know enough about the behavior of most of these materials to know how far they can be safely stressed or how important is the factor of time.

"A very important phase of this problem is the effect of frequency and wave form. We know, for instance, that insulating mater als are affected quite differently by direct current and by alternating current of the usual commercial frequencies but we

know very little about the relative action of these two on the dielectric.

"The question of d.c. stress is becoming very important in connection with transmission of power at high d.c. voltages and the testing of a.c. cables with Kenotron outfits."

Cochrane Corporation,
Philadelphia, Pa.,
Geo. H. Gibson.

"Sodium carbonate in solution in boiler feed water breaks down to sodium hydrate, or caustic soda, which is believed to be the cause of so-called caustic embrittlement of the steel of which boilers are constructed. The action is believed to be more pronounced in high pressure boilers than in low pressure boilers and it also appears that an appreciable time is required for the breaking down of the sodium carbonate. It would be desirable to have quantitative laws expressing the relations between concentrations, temperature, pressure and degree of dissociation. Observations made on a steam boiler under load are summarized in Fig. 4. on page 3, of the enclosed paper, entitled, 'Rational Selection of a Feed Water Treatment,' by C. E. Joos, an Engineer of the Cochrane Corporation.

"It is now becoming the practice to deaerate water in order to prevent oxygen corrosion of piping, economizers, boilers, and particularly hot water service and heating systems in buildings. It occasionally happens, however, that when a deaerator is put in service red water, that is, water carrying oxides of iron, appears at the faucets. Some believe that this phenomenon is due to a reducing action of the deaerated water, which loosens up rust or scale previously formed by the use of undeaerated water in the piping. On the other hand, it may be merely accidental, that is, the rust may have been lying loosely at some part of the piping and may have been stirred up by unusual flow conditions. It would be of service to users of iron and steel piping, as well as to manufacturers of deaerating equipment, to know whether deaerated water has any such reducing or loosening effects.

"In metering fluids by measuring the drop across orifices or nozzles inserted in pipe lines, it is ordinarily assumed that the rate of flow varies directly as the square root of the pressure differential. This relation holds satisfactorily for non-elastic fluids, such as water and oil, and for elastic fluids when the pressure drop is not over 1½ per cent of the initial pressure. At low absolute pressures, however, 1½ per cent becomes a very small differential to deal with and it is desirable that the law connecting flow and pressure drop be determined experimentally. The problem is quite fully set forth

in the report of the Fluid Meters Committee of the American Society of Mechanical Engineers."

Belden Manufacturing Company,
23d St. and Western Ave., Chicago, Illinois,
C. S. Craigmile, Gen'l Supt.

"In the manufacture of electrical equipment, the softness of copper magnet wire used in various types of winding is of very considerable importance. There has never yet been devised an entirely satisfactory method of determining the softness of this magnet wire. I, therefore, suggest that you might consider as a subject: 'A Practical Method for Determining the True Softness of Copper Magnet Wire.'

"As you no doubt know, the common method now used is an elongation test, which is unsatisfactory because of the fact that after copper reaches a certain degree of softness, the per cent elongation decreases. Ordinarily, copper wire which has passed this critical point of softness is the most satisfactory for winding into coils or armatures."

Westinghouse Electric & Mfg. Company,
East Pittsburgh, Pa.,

Thomas Spooner, Mgr. Gen'l Division, Research Laboratories.

"1. Nature of Heat Dissipation.
   (*a*) Study of the mechanism of transfer of heat in forced convection, namely the transfer of heat from surface to stationary air film and thence to moving gas.
   (*b*) A comparison of the heat dissipation from a rotating cylinder with heat transfer from a stationary surface.
2. A Study of Methods of Calculating the Windage of Rotors of Various Forms.
3. A Study of the Mechanism of the Conduction of electricity from a moving metal surface to a stationary carbon brush (the theory should explain the distribution of current, allowable density, heat dissipation and the like).
4. Lubrication.
   (*a*) A study of oiliness in connection with the hydrodynamic theory of lubrication.
   (*b*) A study of the mechanism of abrasion.
   (*c*) What is the origin of dry friction?
   (*d*) A study of the flow of liquid between concentric cylinders with respect to the stability of flow.

5. A Determination of the Mechanical Hysteresis or Internal Friction Constants of various Steels, Bronze, Cork, Rubber and the like.
6. In concentrated solutions of strong electrolytes what is the influence on the electrical conductivity of other electrolytes present in concentrations up to a few per cent?
7. The development of synthetic resins or similar materials highly resistant to concentrated alkaline media.
8. The development of electrical insulating surface coatings or films adherent to metals and resistant to concentrated alkaline media.
9. A more complete and accurate determination of the ordinary physical constants of pure chemical substances.
10. A study of the nature of substances obtained by low temperature charring of cellulose and other organic materials.
11. A further study by chemists of the nature of corrosion.
12. A study of the nature of electric arcs drawn in high vacuum.
13. A study of the motion of arcs under the influence of magnetic fields.
14. Cathode Ray oscillographic studies of the characteristics of arcs confined in various ways such as in tubes and narrow slots.
15. A study of the nature of rectification in copper oxide rectifiers.
16. A study of the dielectric properties of thin films and methods of producing them.
17. A study of methods of elimination of static from belts, in textile mills, and other places where a fire hazard exists."

Radio Corporation of America,
233 Broadway, New York City,
Alfred N. Goldsmith, Vice-Pres.

"Some of the subjects in the radio field which are of major interest at this time are atmospheric disturbances; transmission phenomena at various frequencies, times of day and season of the year; and studies of the best methods of utilizing the common transmission medium for all radio communications by logical and effective classification of services."

Radio Patents Corporation,
10 E. 40th St., New York City,
Alex Nyman.

"Analysis of factors determining the duration of life of paper condensers, in particular, with regard to the methods of impregnation and the qualities of material used.

"Analysis of the factors determining the losses in paper condensers.

"Research work on the best type of electrolyte of the so-called dry electrolytic condensers, the methods of maintaining the electrolytic film under operating conditions and, in particular, the methods of reducing losses in this type of condenser, when operated on alternating current.

"Research work on the use of electrostatic condensers, for the purpose of ameliorating the surge effects on power lines and, in particular, the ability of different types of condensers to withstand surges without deleterious action."

Group B. Mechanical Equipment and Materials of Engineering

American Society of Mechanical Engineers,
29 West 39th St., New York City,
C. C. Worthington, Research Assistant.

"I am enclosing a list of six "suggestions" prepared by the A. S. M. E. Research Committee two years ago for use by students in choosing theses problems. These problems are still live, and I trust may suit your purpose.

"There is another problem that also may appeal to you; namely, Determination of the Effect of Varied Amounts of Moisture in the Atmosphere on the Efficiency of Internal-Combustion Engines. This information is now being sought in connection with the development of an international test code for internal-combustion engines.

"I suppose that you are already acquainted with the fact that The Engineering Foundation, Inc., 29 West 39th Street, New York City, and the Division of Engineering of the National Research Council, may be able to give you suggestions also. In fact, Mr. W. V. A. Kemp, Director of the Committee on Heat Transmission, National Research Council, 40 W. 40th St., has made a special point of formulating problems of the field in Heat Transmission suitable for attack in university laboratories.

"As you undoubtedly know, this Society sponsors cooperative engineering research projects in university and government laboratories. These projects are at present some twenty-seven in number

and represent the type of problem not likely to be undertaken by individual industrial concerns. I enclose a copy of the 1929 Annual Report of this work, in which you will find the various projects described. You will be interested to know that Professor A. E. White, Director of the Engineering Research Dept. at the University of Michigan, was Chairman of the Main Research Committee last year, and would be glad, I am sure, to give you any further details of the work.

1. *Research to Determine the Effect of Moisture in Steam*

"At a recent meeting of the A. S. M. E. Main Committee on Power Test Codes it was brought out that the spirit of the clause covering the effect of moisture as it now appears in the Test Code for Reciprocating Steam Engines was satisfactory but it was the general feeling that something more definite is desirable. It was the consensus of opinion that moisture in steam is detrimental to the economy of an engine and to a disproportionately large extent. Accurate information on this subject is desired particularly by the Power Test Codes Individual Committee No. 5 on Reciprocating Steam Engines.

"Tests to develop definite data on this problem might well be undertaken by students in engineering schools. The Code Committee would be glad to act as a clearing house for the data thus obtained.

2. *Research on Certain Requirements of the Safety Code for Mechanical Power Transmission Apparatus*

"Many of the requirements in this Code are based on insufficient experimental data as to the strength and other properties of the safety devices which are recommended. There would be no unusual difficulty in making tests which would give the necessary information to base the Code on sound technical data.

"Referring to the Code, Sections 25 and 26 show the requirements for (Section 25) keys, set screws, etc., and (Section 26) collars, and couplings. The devices which were approved as being safe have been severely criticized by the industry because they do not function in a mechanical way as satisfactorily as the devices which they replace. This is, first and foremost, a mechanical engineering problem. There is obviously no great difficulty in designing, making, and testing, devices for power transmission apparatus which will be cheap, efficient, and safe. The reason that this has not been done in the past can be laid only to the fact that in all probability, no one has considered these devices of sufficient importance to warrant the attention that they *must* receive before the problem is satisfactorily solved.

"Rule 424 in Part IV. Guard rails and Toeboards. There has been considerable discussion about the strength of guard rails and toeboards used in safety measures. Obviously, a great deal depends on how a guard rail is attached to the floor. Often the method of fastening, for instance wood screws ½ inch long on a flange of a pipe rail is so inadequate that the guard rail is a menace rather than element of safety.

"These are subjects which are very well suited for theses work as students can be allowed to work out their own solutions without a great deal of help from their instructors. It is obvious that an investigation of this work does not require readings of high precision. If the values are known within ten per cent, they would be adequate so far as safety is concerned.

3. *Researches on Machine Tool Elements*

"The following have been suggested as problems suitable for students to undertake:

"(1) It is known that certain bronzes offered by the trade for bearings will not work in conjunction with certain alloy steels owing to abrasive action being set up between the two materials. An investigation with a view to determining the causes of this abrasive action would be very helpful to both bearing manufacturers and users.

"(2) Comparative wear of crank shafts or machine spindles made of low carbon steel and case-hardened and those made of alloy steels and heat treated. There seems to be some evidence that the case-hardened surface wears much less rapidly than the other. Crank shafts for tests could be obtained from the manufacturers.

4. *Research Investigation of the Methods of Fastening Wire Rope*

"There seem to be conflicting opinions concerning the proper method of fastening wire rope and an investigation to determine this seems advisable from the standpoint of the safe use of this material.

"The Bureau of Standards finds the use of zinc satisfactory in socketing wire ropes used for tests. This is the method of fastening recommended in the Wire Rope Specifications of the Federal Specifications Board. In elevator work, however, babbit is more generally used as the elevator industry believes that it is safer to use babbit to socket elevator ropes than to use zinc because of the difficulty in obtaining skilled workmen necessary to socket satisfactorily with zinc. Experiments have been carried on recently at Armour Institute which seem to indicate that babbit and zinc fastenings are unreliable and point out the superiority of the "Truelock" fastening used by the American Cable Company.

"The problem has been referred to the A. S. M. E. Main Research Committee with the suggestion that it be brought to the attention of engineering schools as a fit problem for either faculty work or for student theses work: It should include an investigation into the existing methods of fastening wire rope, their relative merits, their action under load, strength of fastening in relation to the strength of the rope, etc. It would seem that there need be no expense in conducting this research other than for materials used in the tests.

5. *Research in Applied Mechanics*

"Consideration of the aspects of mechanical design in the electrical field have long been neglected particularly in the mechanical and electrical courses in engineering schools. Even such celebrated works as those of Arnold and Russell treat primarily of the electrical aspects of electrical machinery design. The professional engineer knows that consideration of the mechanical design problems is of equal importance but has little information available to tackle them with. The following two phases of the problem are of first importance and most require study:

"(1) A recapitulation and further analysis of the electromagnetic reactions, as well as the general torque characteristics and energy relations both from the aspect of applied loadings on its own mechanical structure, and as to the application in driving machinery, etc.

"(2) A detail research and analysis on the mechanical structure of electric machines themselves, such as the strength of rotor casings, bearing supports, shafting, revolver field poles, spiders, etc., and the general problem of reduction in weight of electric machinery.

6. *Research on Grinding*

"This is a subject of considerable interest to manufacturers and users of abrasives, grinding wheels, and grinding machines. There are many important problems in this field for which industry is desirous of a solution.

"The following problems are those to which students might contribute:

"(1) Establishment of exact methods of grading grinding wheels.

"(2) Comprehensive study of fundamentals of grinding such as:

a. Selection of abrasive for specific materials.

b. Determination of relations between wheel speed and rate of travel to rotating speed and nature of work.

c. Advantages to be derived from various kinds of coolants.

d. Relation of rigidity of machine and accuracy of balance wheel to quality of work.

7. *Research on the Strength of Cylindrical Vessels Under Pressure*

"It is the conclusion of the Boiler Code Committee that in view of recent developments there is one subject in particular that appears to be greatly in need of investigation, namely, the strength of cylindrical vessels spherical heads, under external and internal pressure. Reliable data on this subject are lacking and the following is suggested for research:

"(1) Computation of strength of inner and outer shells of a jacketed cylinder with staybolts between shells;

"(2) Computation of strength of inner shell of jacketed cylinders when there are no staybolts;

"(3) Computation of strength of cylindrical furnaces for same general construction as stated in items (1) and (2).

8. *Research on Heat Transfer between Condensing Vapor and Liquids*

"In connection with surface condensers and feedwater heaters data on the transfer of heat between the vapor and the condensing liquid are not well enough established. More accurate information on the water side and vapor side coefficients is needed. Considerable work has already been done along this line by G. A. Orrok (*A. S. M. E. Trans.*, vol. 32, 1910); E. E. Wilson (*A. S. M. E. Trans.*, vol. 37, 1915); McAdams, Sherwood, and Turner (*A. S. M. E. Trans.*, vol. 48, 1926). Further single tube experiments on several sizes and lengths of tubes should be carried on to determine the effect of diameter and ratio of length to diameter on heat transfer. All these determinations should be taken with temperatures on the surface of the tube so that the vapor and water coefficients can be separated.

Chrysler Corporation,
Detroit, Michigan,
G. L. McCain, Research Engineer.

"There have been some suggestions made that there is such a mass of data contained in the papers presented at various times for the S. A. E., A. S. M. E. and the I. A. E. Societies on various subjects, that it is difficult for an engineer with limited time to review progress which has been made, in any reasonable time.

"The suggestion was that if a group of college students who were interested in studying a particular line, such as fuels, manifolding, brake lining testing, a review of the transactions of the societies mentioned, and perhaps others, which would bring out interesting data and show whether certain fundamentals have been proven by an agreement of tests made.

"The general idea of the above suggestion can be carried out along any line which has had the attention of engineers over a period of years.

"Another subject, about which data have been more or less crowded, is that of brake lining and its relation to uses in automobiles. Proper materials for the manufacture of brake drums is a big problem. The coefficient of brake lining when new is apt to be quite different than when it is half worn out; and also, the question has been raised as to whether the coefficient of friction is the same under all speed and road conditions.

"Many tests have been made of automobile horns to determine absolute or comparative penetrating properties of the sound. A study along this line would include the source of the sound and the effect of the sound upon the driver in the car ahead and under variations of speed and road conditions.

"Too little study has been given the proper analysis by proper authorities on what constitutes a satisfactory or safe automobile. Every person's reactions to continually changing conditions in traffic, are different. This subject, I believe, has been given some attention, only recently, and it seems to us that in view of present conditions that a study along this line would be quite timely."

The Hoover Company,
2300 Willoughby Tower, Chicago, Illinois,
W. F. Hudson, Asst. to Vice-Pres.

"We are listing below some subjects which occur to us as having a broad enough interest to warrant consideration by Universities. We have given all of these subjects some attention, but they are, as you will realize, broad enough to warrant going considerably further than one laboratory can carry them.

"1. Air and gas flow through small orifices at low pressures.

"2. Fundamental data and design characteristics for small fans operating at high speed and at low pressures.

"3. Investigation of steel for dies used in die casting.

"4. Power losses and characteristics of small ball bearings—also means for sealing them to prevent entrance of dirt and loss of the lubricant.

"5. Small motor design data.

"6. Eddy current losses in small motors.

"7. Cooling of small motors, including ventilation.

"With reference to some of the above, might say that so far as we know there is no published information on Item 1. We did carefully calibrate a number of small orifices and will probably publish our work in the near future, but there is much yet to be done.

"As to small fans, we have seen no published data, and are now doing considerable work trying to determine how nearly the avail-

able design data for large fans may be applied when designing those such as are used by us.

"Strange as it may seem, few people seem to realize that in spite of a ball bearing having low friction losses, we may heavily load a small motor simply because the felts are not properly fitted. It is my personal feeling that if we could properly seal the small ball bearings, the bearings would not need attention for a great many years, and possibly not for the life of the motor, but while we have made considerable progress in bettering bearing protection, our ideal has not been reached, and we believe this to be a problem of interest to a number of the industries.

"Again, on small motors, we have done a great deal of work and have accomplished much, but still, in our designs certain assumptions must be made, and we have still to develop accurate methods for measuring certain losses.

"With relation to steel for die, might note that recently we had one die which gave us a life about three times the average. We are carefully investigating this particular die, feeling that from it there may be much to be learned. Certainly it would be a wonderful contribution if some University research would enable the die life to be doubled.

Small Bearings, Ball.

(*a*) Lubrication for high speed, small bearings to retain lubricant and prevent entrance of dirt.
(*b*) Effect of mounting in plastic material, on noise.
(*c*) Measurement of friction of various speeds and loads.

Sleeve.

(*a*) Develop device to permit investigation of friction of small bearings at high speeds and small loads.
(*b*) Means for lubricating small bearings.

Dynamometers.—Devices to measure small amounts of power and very small forces.

Measurement of Time Intervals.—Development of Compact Device of low weight to measure elapsed time for operation with *Direct Current* circuits.

Better control of rubber compounds during curing operations.

Aging investigations for rubber.

For Metallurgy Department—Causes of "heat cracking" or "surface checking" of die casting dies used for pressure casting of aluminum alloys. Influence of heat treatment and composition of steel on durability in service.

Heat transmission and dissipation in fractional horsepower motors.

Investigation of contact drop for carbon brushes in fractional horsepower motors.

The DeLaval Separator Company,
Poughkeepsie, N. Y.
A. E. Flowers, Engineer in Charge of Development.

"1. Is there a relationship between the quantity and kind of organic acids in non-aqueous (oily) solutions and the E. M. F. which these solutions will show in an electrometric titration cell? For example, will the 0.001 N solution of acetic acid in butyl alcohol show a higher E. M. F. than a 0.001 N solution of benzoic or oleic acids? We know that such acids, if present in oils, can have the acidity measured by the electrometric titration method, but the results as now obtained do not reveal anything in regard to the nature of the acids. A study of the relationships between the E. M. F.'s and the type and quantity of pure acids in non-aqueous solutions may throw some light on this problem.

"2. Is the "oiliness" of an oil affected by constant service with or without continuous removal of suspended impurities and/or deterioration products? It is at present quite commonly the practice continuously to remove suspended impurities from lubricating oils but not the dissolved deterioration products. The so-called "oiliness" of any oils has received considerable attention and some advertising, but little, if any, information has been offered on the effect of service on "oiliness."

"3. What are the processes and results of the oxidation of hydrocarbons, particularly of those of given, known chemical composition and of high molecular weight?

"4. What are the relations between wear and viscosity at temperatures of operation of automobile engines, and what are the minimum viscosities for reasonable wear and service? Further, and related to the above, is the question of the effect of dilution and if diluted or pre-diluted, oils give the same wear-viscosity results as oils kept free from dilution.

"5. Why does the Conradson Carbon Residue of filtered used automobile crankcase oil increase with use and what effects does this increase in carbon residue have on lubrication or "oiliness" and on carbon deposits in the engine and exhaust passages?

"6. What are the settling rates of different sized particles in liquids in the three regions of turbulent or semi-turbulent movement, non-turbulent movement (where the opposing forces are due to viscosity primarily) and in the regions of lowest velocity where colloidal and semi-colloidal conditions exist and where Brownian movements may be present?

"7. How can machinability be conveniently tested for shop information and what are the relations of machinability to physical properties and physical and crystalline structure?

"8. How can the deep drawing properties of sheets be determined for information as to acceptability of material and methods to be followed in shop practice?

"9. Investigate the characteristics of metal cutting by means of the combination of a high-speed motion picture camera record of the appearance and position of the chips and the cutting tool point, synchronized with a carbon pile pressure-deflection instrument actuated by the infinitesimal deflections of the cutting tool for the purpose of measuring the instantaneous cutting tool-point pressures using an oscillograph or an Einthoven String Galvanometer for measuring and recording the current through the carbon pressure pile and therefrom the instantaneous cutting tool pressure, tool-deflection, by means of the pressure on the carbon pile, and resulting carbon pile pressure and electrical resistances.

"10. Investigate the possibility of developing convenient means and apparatus for measuring the frequency (pitch) and loudness of noises.

"11. Investigate and develop methods and apparatus for measuring the frequency, direction and amplitude of vibrations.

Firestone Tire and Rubber Co.,
Akron, Ohio,
W. T. Runals, Eng. Dept.

"1. Studies in Standardization as applied to small motor control and small electrical appliances used by large industries. This subject should be treated in the nature of test methods for determining the characteristics of new appliances or a check on old ones.

"2. Studies of electrical braking as applied to a motor—dynamic vs. plugging, comparing the mechanical shock on driven machinery and mechanical and electrical stresses on motor winding. To date a very limited amount of data is available. This subject is quite important inasmuch as the above-mentioned types of braking are rapidly replacing the old solenoid-operated brakes.

"3. Electrical heating as applied to cutting and curing of rubber and also pre-heating rubber equipment such as tube machine die heads by the use of electrical force, by the use of resistance or induction method. There is a vast field for this use of electricity in the rubber industry."

United States Radiator Corporation,
127 Campbell Ave., Detroit, Mich.,
R. F. Connell, Mgr. Testing Laboratory.

"There are probably many branches of research that would lend themselves admirably to the equipment of college test rooms, but I

cannot definitely name any with the assurance that the subject is not receiving attention at the present time.

"There does appear to be, however, an almost total lack of authentic data as to the relationship of the combustion chamber area to the proper burning of each pound of oil when using different types of oil burners. This applies to the burner that either atomizes, vaporizes, or employs a hearth in the firebox, and I am quite sure that most of the nationally advertised burner manufacturers would be only too willing to supply equipment to universities for test purposes.

"The relative merit of extended fin radiation as applying to copper, aluminum, steel, or cast iron is another subject I believe ideally suited for college investigation."

A. O. Smith Corporation,
Milwaukee, Wisconsin,
T. McLean Jasper, Director of Research.

"The first problem covers work on gas and inclusions in steel and their effect on corrosion, strength and ductility. This problem is being undertaken by the United States Bureau of Standards, Watertown Arsenal, and about three steel companies. Up to the present time very little progress has been made.

"The next problem I would suggest is a comprehensive study of the theories of failure of metals with tests to demonstrate the correct theory. I might add that the tests made to demonstrate the maximum shear theory are not free from severe criticism, and the writer finds this theory to be without good foundation. A study of Guest's work will bring this out.

"Another problem of great interest to industry is the development of a comprehensive mathematical solution for the stress in flanges used for pipe joints. It has been very clearly demonstrated that Water's formulae are of questionable value, and at most only cover a very small range. This problem is one which has to do with a considerable number of factors. There are many problems for stress analysis in connection with vibration for which very meager data are available.

"As an after thought I might say that industry is crying for refractories to stand exceedingly high temperatures, around 4000° F. Any one who can develop such a refractory and properly bind it into a mass so as to stand for a considerable time would confer a great boon on industry."

Crucible Steel Company of America,
New York City,
John A. Mathews, Vice-Pres., Executive Dept.

"At the present rate at which industrial developments are going on it is hard to decide upon what is, or what is not, important. Information which is not important today is inquired for tomorrow. I have in mind such properties of materials—especially corrosion resistant materials—as elastic coefficient, thermal conductivity, in higher ranges than are usually met with, coefficient of friction, etc."

The American Brass Company,
Waterbury, Conn.,
W. M. Bassett, Metallurgical Manager.

"1. Fundamental information about the electrical conductivity of metals and alloys.

"2. Study of volume changes in alloys during the process of solidification.

"3. Fundamental research in the nature of welds made upon steel, iron or other metals with non ferrous welding rod such as Tobin Bronze, Manganese Bronze, Phosphor Bronze and Silicon Bronze.

"4. Effect on the corrosion resistance of copper by such addition agents as aluminum, arsenic, silicon, zinc, tin, manganese and nickel.

"5. Resistance to corrosion of materials used in overhead construction for the electrification of steam railways. The principal corroding agents are the gases from steam locomotives, especially if high sulphur coal is burned.

"6. Resistance to corrosion of materials used in petroleum and natural gas industries. Here again the most active corroding agent is due to the use of high sulphur crudes which are more and more being utilized in the petroleum industry."

The New Jersey Zinc Company,
Palmerton, Pa.,
W. M. Peirce, Chief, Metal Research Division.

"Because of the universal use of zinc pigments in rubber compounds, we are interested in problems connected with rubber and it is our belief that there are many possible new uses of rubber as an engineering material but that there are engineering problems in connection with the development of such uses. Engineering studies of possible uses would doubtless suggest desirable or necessary modifications in the properties of compounded rubber which would serve as a guide for new research work on the part of rubber technologists.

"In the field of metals there is little doubt that there is much to be learned concerning the effect of the rate of deformation in mechanical testing. For example, curves showing the change in ultimate tensile strength, as the rate of extension is varied from the very low values, approaching those that occur when a dead load is applied in a creep test, to the very high rate which is obtained in an impact tensile test, would undoubtedly prove highly interesting on many materials, particularly on non-ferrous metals. This is a type of problem which is important and yet not likely to be thoroughly investigated by any one industrial laboratory and it would seem to be of the sort which could well be undertaken by a university engineering laboratory.

"In some schools metallography is considered an engineering subject. If you classify it as such, it may be pointed out that the constitutional diagrams, even of the common alloy systems, are few of them accurate especially with regard to solid solubility limits. Many of the less common ones are little better than guesses based on a few cursory experiments. These diagrams are of more than academic interest in modern-day metallurgy and there is certainly a tendency to look to university laboratories for help along this line."

International Harvester Company,
606 South Michigan Ave., Chicago, Ill.,
E. A. Johnson, Director of Engineering,
O. B. Zimmerman.

"1. Materials: While a great deal of work has been done on shop operations, there still is I believe much to be gained from a complete analysis, both in ferrous and non-ferrous metals, on the optimum material to meet the following shop operations taken individually:

(*a*) Simple forging.
(*b*) Welding by fire.
(*c*) Welding by electricity.
(*d*) Drawing, as in wire.
(*e*) Drawing, as in deep forming.
(*f*) Punching.
(*g*) Shearing.
(*h*) Spinning.
(*i*) Machining.
(*j*) Threading.
(*k*) Drilling.

"Others might be added.

"By these separate studies of the characteristics of various metals we should gain a knowledge of certain factors not now known.

We, of course, in manufacture have to deal with and choose our material because of a combination of two or more of these operations performed upon a part which makes for a compromise judgment on the subject. This study looks to me as one which could be readily carried out because it does not involve excessive expenditure for materials and can be analyzed with simple equipment.

"2. Materials: To our industry the subject of optimum material to meet soil erosion on farm tools is of very great importance, hence a detailed study of the relative erosive action on various materials on different kinds of soils seems to me would be a very valuable one to carry out. In a problem of this kind our industry, or this company could profitably co-operate to determine the factors involved.

"There is, also, a general question of the determination of the relative friction or draft produced by various materials involved in the same machine part which is subject to soil erosion. It is a well known fact that the huge amount of energy dispelled each year in turning over the soil is greater than that of all industry combined and a reasonable reduction in friction or draft of the tillage tools which require the greatest amount of energy would be a great help to the farmer, hence the importance of this question.

"3. Preservation of Farm Products: The question of preservation of perishable farm products needs much more attention than it has received. While considerable work has been done on this question it does not seem that enough work has been done to give us the final answer to this question. For example, the storage of potatoes and roots in various types of cellars, the storage of apples and other fruit involves extensive study in temperature, ventilation, moisture control, etc. It may also possibly involve this very interesting factor, namely, that these storage bins could be partially sealed and subjected to other gases than regular air. For example, there might be some very valuable results come about by subjecting these cellars to a gas such as carbon dioxide.

"4. Agricultural Wastes: While considerable work has been done on the use of straw in corn stalks there are still many others which should have attention. For example, the possible utilization and transformation into commercial products of waste apples, oranges, tomatoes, spoiled grain or corn. This naturally would have to involve the general question of a simple apparatus which could be made useful to a farmer or group of farmers.

"5. Fuels: There are many indications that we are not completely solving the fuel question for internal combustion engines although we are well on the way, as indicated by increased efficiency. I, however, think that there is one very important investigation which needs to be carried out and which may from the present day

knowledge seem like a non-commercial one, that is the development of studies in the molecular structure of various hydro carbons. We hear of extensive investigations on the structure of molecule and very valuable work has been done on this question. A practical application of the same is the following, which might be stated thus:

"What are the conditions which control the formation of the several hydro carbon isomers of a given chemical composition, such as C_6, H_2, C_7 and H_9, granting that these isomers can ultimately be produced commercially?

"Further, what is the relative efficiency of these several isomers with respect to one another when used in a refined high-speed internal combustion engine?

"This is a very important chemical engineering subject.

"6. Design: Plain cylindrical bearings are still extensively used in machines and undoubtedly always will be where simplicity is desired, and while a great deal of attention is being given to ball and roller bearings a complete analysis of plain cylindrical bearings and the materials therefor has not been worked out to a finality. The subject of grooving of bearings, the tolerances desirable and the relation of pressure areas produced in their operation wants considerable study to reduce wear. It would seem to me that a complete rounding up of this problem would attract a great deal of favorable comment and also be extremely valuable to a large number of moderately sized industries."

Ingersoll-Rand Company,
11 Broadway, New York City,
F. W. O'Neil, Vice-Pres. and Chief Engineer.

"(1) In the so-called natural gases we know that the value of N, or the ratio of specific heats, varies widely depending upon the proportions of the various hydro-carbon compounds which constitute the gas. So the problem would be: Knowing the constituents of the gas—i.e., the amount of methane, propane, etc., what would be the value of N?, as this factor influences the horsepower for compressing the gas and also the volumetric efficiency of the compressors used for that purpose, due to the wide variation in the expansion line.

"(2) It is known that the so-called perfect gases do not behave according to the old established theories of Boyle's law, at great densities; and interesting research work could be done by knowing how far the mathematics of gases at great densities depart from the law of so-called perfect gases.

"In order to be useful in industry, this latter investigation should be carried at least to 15,000 lbs. per square inch."

GROUP C. LIGHT, RADIATION, HEATING

Illuminating Engineering Society, Committee on Research, 29 West 39 St., New York City.

"1. The study and standardization of methods of measuring and recording candlepower values of high intensity beams, particularly of the searchlight type.

"2. A study of flicker of incandescent lamps operated on 25 cycle alternating current, including conditions of lowered voltage, colored lamps and direct versus reflected illumination.

"3. Temperatures of enclosing globes, and a study of moisture condensation and breathing in so-called dust-tight units.

"4. A study of stream-line design of lighting glassware to minimize dust collection.

"5. The effect of initial current surges in make-and-break switching mechanisms controlling large wattage lamps.

"6. Study of accident locations to determine relation of illumination.

"7. Survey of school rooms for conformity with school lighting code with recommendations for improvement.

"8. Study of legibility of signs, for verification of established formulae.

"9. Study of silhouette in street lighting with reference to different conditions.

"10. Study of motor vehicle headlighting.

(*a*) With reference to interference of opposing lights.

(*b*) With reference to different character of road surface.

"11. Study of glare from headlights on well-lighted streets to determine whether or not the disadvantage of powerful headlights is greater than the advantage.

"12. Influence of bright extraneous light-sources as affecting the ability of the motorist to see at night.

"13. A study of the minimum illumination requirements for night-driving.

"14. Study of legibility of automobile rear-license plates under night conditions.

"15. Study of street lighting as affecting the hazard to pedestrians where motor-cars are turning corners and the pedestrian is outside the headlight beam.

"16. Method of measuring the spot-diameters of different types of lamps at different distances for application to the design of electric signs.

"17. Relations between intensity of illumination and allowable brightness of light-source in field of view.

"18. Investigation of diffusing-glass enclosing-units with various types of fitters or holders, such as dull brass, mirrored glass, white

paint, white glass, aluminum finish, porcelain enamel, etc., to determine the effect of the inside surface of the holder.

"19. Comparative tests on standard lighting equipment such as RLM standard dome, prismatic glass, glassteel diffuser, and so-called dust-proof equipment to determine the effect of dust accumulations.

"20. Study of the effect of increased street lighting on show-window lighting.

"21. Investigation of photo-electric cell, construction versus color sensitivity, and proper filters for use in photometry.

"22. Analysis of lamp-performance under vibration.

(*a*) Method of recording vibration.
(*b*) Apparatus to reproduce definite vibration.
(*c*) Effect on lamp-performance of different periods, wave-form and combinations.

"23. Compilation of bibliographies on:

(*a*) Street lighting fundamentals.
(*b*) Glare.
(*c*) Effect of illumination upon production.
(*d*) Relation of light to safety.
(*e*) Physical photometry.
(*f*) Heterochromatic photometry.
(*g*) Effect of light on plant growth.
(*h*) Fading of colored materials by daylight and artificial light.

"24. Study of methods of measuring very low illumination-intensities.

"25. Irradiation effects using colored light; the study to be confined chiefly to the media and the problems involved in sign design.

"26. A study of the reflection-factors and depreciation values of aluminum and white paints when used in industrial interiors and on machinery.

"27. A study of the rate and amount of depreciation of the light-output of lighting systems as found in various industries.

"28. A study of the suitability of chromium for reflectors for all classes of lighting service.

"29. Possibilities of lessening flicker of projected motion-pictures with the use of perforated projector shutters.

"30. Possibilities of lessening flicker of projected motion-pictures with transparent colored sectors in the projector shutter instead of the more usual opaque sectors.

"31. The effect of energy-cost on kilowatt-hour consumption for residences.

"32. The design of a suitable optical system with standard lamps for the lighting of the ear, nasal cavities, mouth, etc.

"33. A study of the comparative cost of artificial light and daylight in an industrial and an office building.

"34. Daylight illumination from courts and light shafts.

"35. Effect of piers, columns, mullions on natural illumination of interiors.

"36. Prediction of sunshine in buildings.

"37. Effects of using glare-reducing coatings on windows.

"38. Further data on control of light from windows.

"39. Further data on effects of dirt on windows and methods of cleaning.

"40. Further data on relation of inside to outside illumination by daylight.

"41. Effect of adjacent buildings and other light obstructions upon daylight illumination.

"42. Relation of labor turnover to natural lighting in industrial and commercial buildings.

"43. Relation of daylighting to architecture, with special reference to residences, schools and industrial buildings.

"44. Advantages and disadvantages of direct sunlight and very high intensities of natural light in buildings.

"45. Relation of production to natural illumination.

"46. Further information on the problem of waning daylight.

"47. Effect of painting on natural illumination of buildings.

"48. Effect of windows upon glare and visual functions.

"49. Diffusive qualities of window shades.

"50. Compilation of data and methods for computing natural illumination in form useful to architects."

Lighting Subjects Suitable for Science Students and Scientists

"1. The transmission characteristics of various types of sheet glass, parchments and fabrics. A study of the difference in transmission for incident light having a beam characteristic and for diffused light.

"2. The effect of colored light on vegetable and animal organisms.

"3. The penetration and change in color of light projected through liquids.

"4. Study of visual habits as affecting visibility.

"5. Relative effects of shape, color, size and intrinsic brilliancy of light-sources at the threshold of vision.

"6. Reflection characteristics of natural colored objects, such as vegetation, flowers, etc.

"7. More extended study of optimum illumination for Snellen Chart, including ink for the letters, style of letter, surface to take the imprint, contrast, etc.

"8. Change in spectral composition of daylight throughout the day and at different seasons and locations.

"9. Development of methods for measuring both retinal and muscular eye-fatigue.

"10. Effects of natural and artificial light on eye-fatigue.

"11. Study the following factors in glare and vision:

(*a*) Similarity of effects resulting from a glare source in the field of view and the brightness of field to which the eye is adapted.

(*b*) Relation between glare effect and the angle and position of the glare source with respect to the line of vision.

(*c*) Effect of glare on accuracy of vision.

(*d*) Effect of glare on speed of vision.

"12. Determine conditions under which a light-source in the field of view is on the borderland between advantage and disadadvantage to vision.

"13. Determine whether dazzle-glare is

(*a*) A function of illumination at eye.

(*b*) Independent of brightness, size or distance of lamp when illumination at eye is maintained constant.

"14. Develop methods for evaluating glare.

"15. Comparison of results with flicker and equality-of-brightness photometers under different conditions, such as varying field size and brightness.

"16. Effects of color of coatings of integrating spheres.

"17. Detailed study of the conditions under which the sphere reflectometer gives correct results."

General Electric Co., Incandescent Lamp Dept.,
Nela Park, Cleveland, Ohio,
Zay Jeffries.

"The Incandescent Lamp Department of the General Electric Company is interested in stimulating fundamental research on the nature and properties of radiation.

"We are also very much interested in the biological aspects of radiation, especially ultraviolet, visible and infra-red radiation."

Carrier Engineering Corporation,
850 Frelinghuysen Ave., Newark, N. J.,
C. M. Ashley.

"While we have a great number of pressing problems in research many of which would be of general interest, there are comparatively few adapted for college research personnel and facilities. One,

however, which seems to the writer particularly suited, is the problem of radiation due to sunlight as affecting the heat gain to buildings. This problem might well be subdivided into a number of separate problems, some of which might be:

"1. The effect of sunlight radiation passing through windows of a building. This might be further subdivided into a study:

a. Clear windows.
b. Frosted windows.
c. Windows with various types of shades.

"2. The effect of sunlight radiation through walls. Walls of different thickness and exposure might be considered here also the instantaneous effect and the lag due to the heat capacity of the wall.

"3. The effect of sunlight radiation on roofs would make another interesting study.

"Among the things which could be studied would be the effect of ventilated or non-ventilated air spaces or both in sloping and flat roofs also the effect of varying amounts of insulation on roof or ceiling.

"The researches which I have outlined above are, I realize, rather ambitious but I believe that it would be possible to subdivide these and have any individual researcher cover a small portion of the field and still make a valuable original contribution.

"So far as I know almost no work has been done on this subject, and what work has been done has been of a type which has not made it easily applicable to actual conditions of building construction.

"The writer has done considerable theoretical study along these lines, and would be glad to make any further suggestions as to methods and what we deem to be the objects of a series of research problems such as we have outlined. You, of course, appreciate that such knowledge would be very helpful both in the design of buildings and also in the application of air conditioning to them."

Group D. Chemical Industries. Paint, Oil, Cement, Cellulose.

Institute of Paint and Varnish Research,
2201 New York Ave., N.W., Washington, D. C.,
H. A. Gardner.

"During the past three months we have been making a survey of research problems for the Joint Research Committee of the A. C. S., A. S. T. M., and Scientific Section of the American paint and varnish industry. The information is nearly all available, and will be put in form within two or three weeks."

The Truscon Laboratories,
Detroit, Michigan,
R. A. Plumb, General Director.

"1. When practically all pigments, with the exception of titanium, are ground in oils or varnishes a colloid of the metal in the paint film is formed and these colloids all carry electrical charges. When paint settles or when the colloids break out of solution on standing in the package, settling is promoted and breaking of the colloid takes place through the union of the positive and negative colloids of metals which have gone into solution in the oils or varnishes.

"If the charges on these metal colloids with the fatty acids or resinous acids could be determined and only charges of the same electrical sign be allowed in the solution, there would be very little settling in the paint, and there would be no tendency for breaking out, or "livering" as it is generally described.

"2. There are a great many tons of wax that is procured in the industry by the dewaxing of Damar for lacquers. It impresses us there is some opportunity for research to determine a commercial application for this wax. If it could be salvaged the saving should represent a very large contribution to the lacquer industry.

"3. The pigment zinc is not compatible with ethyl lactate in lacquer. This is due to the hydrolysis of the ethyl lactate by the zinc oxide. If some way could be found of stabilizing zinc and ethyl lactate much better flow could be given to most spray lacquers made today, and it would be of great assistance in the preparation of lacquer for application by dipping.

"4. Our industry has an unsolved problem in the flooding of paint pigments, such as greens and grays. The addition of rosin acids to the paint does not entirely stop this tendency."

Portland Cement Association,
33 West Grand Ave., Chicago, Illinois,
F. R. McMillan, Director of Research.

Cement.

"Study of methods of determining particle size and size distribution of finely divided materials including cement. Should include study of air analyzer, Noebel elutriator, microscopic projection, or other methods.

"Effect of hot cement on temperature and behavior of fresh cement on properties of hardened concrete.

"Review and comparison of foreign and American methods of testing cement.

"Aggregates: Development of a reliable test for absorption of fine aggregates.

"Effect of organic material in fine aggregates on resistance of mortar and concrete to freezing and thawing.

"Effect of surface texture of coarse aggregates on transverse, tensile, and compressive strength of concrete.

"Effect of heating aggregates and water on strength of concrete.

"Volume change of different types of aggregate when subjected to wide ranges in moisture content and in temperature.

"Investigation of properties of cinder concrete; influence of cinder aggregate on corrosion of reinforcing.

"Methods of determining durability of fine and coarse aggregates.

Plain Concrete.

"Effect of vibration during setting on strength of concrete.

"Effect of temperature at time of test on strength of concrete.

"Effect of calcium chloride and sodium chloride on hardened concrete and methods of protection against their action.

"Effect of long continued mixing on strength of concrete.

"Influence of high pressure steam curing on strength, volume change, and resistance of concrete to corrosion in sulfate solutions.

"Study of fatigue of concrete under (*a*) slowly applied loads, (*b*) impact, (*c*) high frequency vibration.

"Effect of high and low temperatures on strength of concrete at different ages.

"Investigation of the uniformity of concrete in deep sections when wet mixtures are used.

"Study of the temperature in concrete slabs as influenced by methods of curing.

"Study of the influence of moisture content at time of test on flexural, compressive, and tensile strength of specimens of different size.

"Strength relations for different types, shapes and sizes of mortar and concrete specimens at different ages.

"Development of a method of making wear tests of concrete.

"Development of methods of making absorption tests of concrete products.

"Study of the durability of finish coat stucco mixtures.

Reinforced Concrete.

"Study of the effect of coatings and admixtures on the bond resistance of concrete.

"Investigation of the initial stresses developed in steel and concrete due to shrinkage, and their effect on the stresses in flexure.

"Study of shearing stresses in webs of shallow beams and methods of web reinforcement."

Johns-Manville,
Manville, New Jersey,
A. M. Hamblet, Mgr. Tech. Research & Development Dept.,

"Dr. B. Townshend, our chief physicist, has suggested the following list of subjects for university research work:

"1. The cause for the weakening by water of materials made from Portland Cement.

"2. The quantitative chemistry (rates of reaction, etc.) of the action of alkali sulphates on cement materials.

"3. The general chemistry of cement materials as regards their resistance to chemical agents.

"4. The quantitative relationships between porosity, pore size, pore distribution and thermal conductivity.

"5. The quantitative relationships between porosity, pore size, pore distribution and acoustical absorption.

"6. Development of a method for determining the thermal conductivity of insulating materials with engineering accuracy which will be more rapid than conventional steady flow methods."

The Atlantic Refining Company,
3144 Passyunk Ave., Philadelphia, Pa.,
J. Bennett Hill, Chief Chemist.

"1. The determination of critical temperature and pressure of the pure hydrocarbons and of mixtures of two or more.

"2. Development of an apparatus for determining ignition temperatures that will enable the prediction of compression temperatures necessary in a Diesel engine.

"3. Development of a method for determining the flame temperatures in an inclosed chamber such as the cylinder of an internal combustion engine.

"4. The determination of the specific heats of hydrocarbon vapors.

"5. The study of the effect of catalysts, type of spray, and fuel on the rate of combustion in a chamber as in the Diesel engine.

"6. The determination of the adhesion of various liquids to polished bronze and steel surfaces in order to obtain information relative to the "oiliness" of various lubricants.

"7. The determination of the friction of various lubricants under conditions where a true fluid film does not separate the bearing surfaces.

"8. The influence of such factors as dissolved gases and types of surface upon fluid film lubrication.

"9. Determine the rate of wear of a bearing surface when lubricated with various oils including substances which increase the "oiliness."

"10. Study of the effect of density, temperature and velocity of air through a venturi tube on the amount of gasoline delivered by a jet inserted in the air stream."

Standard Oil Company of California,
San Francisco, California,
R. A. Halloran, Mgr. Research & Development Dept.

"Assuming that 'engineering research' is intended to cover the broader field of physics, there are listed herewith a number of problems which we believe could be included to advantage in your list.

"(1) Characteristics of flow of mixtures of vapors, or gases, and liquids (engine manifolds, tubular stills) including the effects of

(*a*) Mixture ratios.
(*b*) Properties of each component.
(*c*) Velocity of flow.
(*d*) Shape of duct, effect of return bends, elbows, etc.

"(2) Thermal properties of petroleum oils at high temperatures (up to 850° F. for liquids, and to 1050° F. for vapors),

(*a*) Specific heat.
(*b*) Latent heat.
(*c*) Expansion coefficient (liquid)
(*d*) Thermal conductivity.
(*e*) Specific volume of vapors.
(*f*) Critical conditions.

"(3) Heat transfer, especially between viscous liquids.

"(4) Effect of viscosity on orifice meter measurement.

"(5) Fractionation; determination of a relationship between the properties of hydrocarbon mixtures and the results of distillation under equilibrium conditions.

"(6) Determination of the solubility of gases in liquids at various pressures and temperatures. For example,

(*a*) Gases: methane, ethane, propane, butane, ethylene, butylene, etc.
(*b*) Liquids: acetone, alcohol, glycol, chlorydin, furfurol, tetralin, benzol, pyridine, etc., and various fractions from petroleum.

"The above problems are all intimately interrelated with engineering design. For that reason a certain amount of research work on these subjects is carried on within the industry, but the field is broad enough to justify the inclusion of such problems in the research activities of universities."

The Celotex Company,
919 North Michigan Ave., Chicago, Illinois,
E. G. Lathrop, Director of Research.

"One of the problems which we would suggest worthy of study is "Flow of paper fiber stock in pipes and through pumps, and the effect of hydration of stock on such rates of flow."

Arthur D. Little, Inc.,
Cambridge, Mass.,
W. J. Murray.

"In my own work I constantly meet problems in non-aqueous hydraulics in which the fundamental data for their solution are lacking. The chemical engineer constantly must consider the flow of oils, acids, solutions, etc. through pipes or orifices, over weirs, etc. In many cases the data for such calculations are not available. Data on the flow of petroleums through pipes and orifices are fairly complete but for other liquids are still rather incomplete. The flow over weirs is still less complete. The special case of flow over circular weirs of small diameter is incomplete even for water. This problem arises in the design of fractionating columns and other chemical equipment. I believe that the determination of the fundamental constants for fluid flow under the conditions stated above would be of great value to all chemical engineers. It is data that the industry would probably not determine for itself, but if it did determine its results would be available only to the engineers of the firm making the determinations. This study should include the flow of very vascous liquids and even plastic solids.

"The accurate determination of heats of combustion of pure hydrocarbons and other simpler organic compounds would be of great help in estimating other heats of reaction and numerous thermodynamic functions such as entropy and free energy. Heats of combustion are usually accurate to 1 to 3 per cent, but when small differences between large heats of combustion are required, as is usually the case, the error may rise to ten or fifty per cent. I know a case where even the sign of a heat of reaction is uncertain because of inaccuracies in heats of combustion. If the heat of combustion could be put upon a higher plane of accuracy, say about 0.2 per cent probable error, the science of thermodynamics as applied to chemistry would be advanced greatly."

E. I. DuPont de Nemours & Company,
Chemical Dept., Experimental Station, Wilmington, Del.,
Thomas H. Chilton.

"We have considered from time to time several problems that we have not felt justified in undertaking ourselves and have thought suitable for research work at universities. We have in mind, particularly, the determination of the physical constants of numerous engineering materials. We are particularly interested in the viscosity and thermal conductivity of fluids, particularly of such mixtures as are encountered industrially. Accurate data on diffusion constants of various gases and of substances in solution would also be desirable for our purposes.

"We are also interested in the problem of frictional resistance between a gas and a liquid at the interface where they flow past one another.

"There is a great dearth of information covering the specific heats, thermal conductivities and viscosities at elevated temperatures and pressures of the gases commonly entering into high pressure synthesis, these gases being carbon monoxide, hydrogen, methane, ammonia and various alcohols. There is also a lack of information covering the performance of materials of construction employed for pressure vessels when subjected to varying pressure and temperature stresses. The performance of steels that show high fatigue resistance to mechanical stresses is radically different when subjected to fatigue from pressure and temperature stress.

"All of these matters appear to me to fall within the scope of the work under discussion. As you probably know, a considerable amount of work has been done by the Fixed Nitrogen Research Laboratory in connection with determination of physical constants of the simple gases and with hydrogen-nitrogen mixtures. The work is not complete, nor does it cover a sufficiently wide range."

DuPont Rayon Company,
Buffalo, N. Y.,
Ernest B. Benger, Ass't General Manager.

"1. The relation between speed and power consumption of a rapidly rotating body such as a spinning bucket. Does it act as a fan, with power proportional to the cube of the speed as claimed? Is it affected by the contour of the casing, the space between it and the casing, and degree of air circulation permitted? How is it affected by operation in full or partial vacuum?

"2. The design of gears for liquid pumps where positive displacement is desired and where backlash and clearance at the root must be kept to a minimum.

"3. Accelerating and retarding agents for the control of Viscose ripening (similar agents in the rubber industry have given remarkable results).

"4. Mathematical study of a thread winding operation. Can the variation in linear speed which occurs when a tapered end cake is formed on a bobbin running at a constant speed be compensated by the proper traverse speed to take advantage of the helical path of the yarn on the bobbin.

"5. The proper relation between length of staple fiber and twist to secure the maximum of strength in the finished thread and the best equipment for it. (Note staple fiber gives something the textile industry has never had before—control over the length of the fiber. To date every effort seems to be toward adapting staple to the equipment available instead of taking advantage of the new control of length.)

"6. The direct conversion of the energy of combustion to electricity in place of the present and very inefficient round-about cycle of combustion to heated gases, to steam, to mechanical energy, to electricity. (The possible saving by increasing the efficiency of conversion of fuel energy to electrical energy from say the present 20 per cent maximum in the best steam plants, to the 85 per cent that is possible in the cycle of a storage battery, would be enormous.) The aim should be to get away from the heat cycle with its inherent inefficiency, and to a *direct conversion of energy.*

"7. Better utilization of heat energy, both artificial and solar heat.

"8. Improvement of cheaper methods of water purification for commercial use.

"9. The extremely important and continually increasing problem of sewage disposal treatment and anti-pollution methods.

"10. Industrial wastes and drinking water supplies.

"11. Development of comparatively inexpensive rotating machinery for compression work to replace reciprocating machinery, particularly for high pressure operations, such as compressed air, gases, etc.

"12. Development of automatic methods of operating various commercially used equipment, such as compressors, refrigerating plants, etc."

The Koppers Research Corporation,
Koppers Building,
Pittsburgh, Pa.,
F. W. Sperr, Jr., President;
Carl D. Ulmer.

"I am enclosing herewith negative photostatic copy of 'report of Subcommittee on Thesis Subjects Related to the Gas Industry' by Dr. A. R. Powell of our organization, as published in the American Gas Association Proceedings for 1929, pages 1063–68. I believe that you will find Dr. Powell has covered the subject of your inquiry in an able and comprehensive way. In addition to this report by Dr. Powell, I am enclosing a supplementary list of topics for your consideration.

"Mr. Sperr has asked me to say that our organization is ever ready and eager to cooperate in matters of pure research with the teaching personnel in our higher institutions of learning. It is unfortunate indeed that because of so many other pressing problems, Mr. Sperr has been unable to give this matter the full share of his personal attention which it surely deserves.

General Type of Thesis Subject Suitable for University Research

"It is believed that the choice of university research subjects for thesis work has in some cases been somewhat ill-advised in the past, and that the work has thereby lost the permanent value that it should have. The usual error that is made in choosing subjects by either the instructor or the student is that the subject to be worked on is much too comprehensive and involved to be thoroughly covered in the limited time available. Extreme examples of this are the assignment of such general subjects as 'coal carbonization,' 'tar distillation,' and other generalities that involve a scanty survey of the literature, a few small-scale laboratory experiments and then the submission of a thesis which is of no value whatever.

"It is often explained that, although the thesis itself is of practically no value, the student has benefitted, since he has gained some knowledge of the general subject which he has worked on. In most cases this is not true. As a matter of fact, the student has missed the valuable training in research methods which he should receive in the thorough study of some problem which is appropriate in scope to the time available. From the standpoint of student training, and his subsequent value to whatever industry he enters, the latter type of thesis work, that is, a thorough study of some very limited subject, is of the most value. It is obvious that a student after leaving college will be assigned to the study of problems of operation or some other phase of work in the industry, in solution of which the research methods are often of considerable value.

The committee considers it important to emphasize this point, since it is a common failing of students to want to solve all of the important problems of the industry in a short time, and to rather frown on a thorough study of what appears to them to be a minor detail.

"Another mistake commonly made in the choice of thesis subjects is an effort to make the work extremely 'practical.' Unfortunately, pressure is sometimes applied from the outside to encourage this. Quite often, this takes the form of efforts to develop new methods or processes, which are supposed to be directly applicable to industry when the work at the university is finished. Although there are exceptional cases where such work might benefit industry, in the great majority of cases this tendency should be avoided. There are three important reasons why this type of work should not normally be carried on by university students.

"1. It tends to exaggerate the importance of development work in the university research program, and hampers and belittles the more fundamental problems, which the university personnel and equipment are better fitted to carry on.

"2. With very few exceptions, the university personnel is not in the proper position to study the economics of proposed developments and properly to evaluate them before the work is started and after the development has been completed. In the great majority of attempts that have been made to carry on this type of thesis work, a preliminary cost study by one thoroughly familiar with the economic side of the gas industry would have demonstrated the practical futility of the proposed development research.

"3. As a general rule, process development work requires the use of very expensive and large-scale equipment and the expenditure of large sums of money. Attempts to carry out such investigations on a very small scale or with the use of make-shift apparatus will often be valueless.

Some Thesis Subjects Suitable for University Work

"The various general plans which have just been described have been used to some extent by the committee in outlining a few suitable thesis topics, some of which would have to be subdivided into several parts in order to satisfy the time limit requirement for individual work. This list of topics should be considered merely as a typical outline of some subject that can be greatly enlarged in number by some further study and observation, particularly of the newer technical trends of the gas industry.

"The arrangement of suggested topics has been made under the same general headings as used in 'Recent Progress in Science in Relation to the Gas Industry,' with some other headings corresponding to the missing chapters in that book.

1. *The Constitution of Coal*

"There is a real need for studies on the physical and chemical properties and analysis methods for coals of different ranks. Such physical properties as electrical characteristics, coefficients of friction, porosity, strength, hardness, ability to resist weathering, and many others have been neglected. It is suggested that instructors desiring more specific information on such problems should write to H. L. Gandy, Secretary, Sectional Committee on Classification of Coal, Southern Building, Washington, D. C. Chemical reactions, other than those resulting from destructive distillation, should also be given much more attention than in the past. There is need for a method whereby the pure coal substance (free from all mineral matter) may be isolated for study.

"Although a great deal of work has been done in attempting to correlate the action of solvents on coal with coking properties, a good deal of confusion still exists. Further work of a systematic nature is required to clean up present contradictory opinions.

"Artificial ulmins can be formed in coal by the action of oxidizing agents. A study should be made to compare these with natural ulmins, and determine how close the relationship is. Such an investigation might form the basis for determining in the laboratory how different coals will weather and lead to simple methods for determining the extent to which any particular coal has weathered. There is a very real need for a method for determining the degree of deterioration that coal undergoes when weathered in stock piles. There is need for improved methods for determining the softening temperature and coking temperature of coking coal, and of a satisfactory method for determining the consistency of coal between these two temperatures.

2. *Physical and Chemical Properties of Coke*

"Although a good deal of data has been collected on the relationship between apparent specific gravity of coke and the conditions under which it was formed, no thorough study has been made of this relationship in terms of the real specific gravity. Research on this subject might reveal correlating properties of very practical interest.

"So much confusion has existed during the last few years in regard to coke 'combustibility' or 'reactivity' that it would seem to be in order to carry on research along this line under closely controlled laboratory conditions but along somewhat different lines than those followed by numerous others. For instance, cokes containing the same amount and type of ash but of different cell structure might be cut into small cubes of equal size and tested for

reactivity in laboratory furnaces, thereby giving an idea of how cell structure affects reactivity, and then the effects of other variables could be studied, such as ash, volatile matter, etc.

"The ash in coke is of enough importance to warrant some thorough studies and research. In the past, the quantity of ash, its fusion temperature, and a few analyses of ash constituents, have constituted practically all of the information gained. Research is urgently required concerning the different forms of ash which exist in coke, since, contrary to general belief, different physical portions of the ash have entirely different physical and chemical properties. Information along these lines is especially useful in the studies of clinkering and of dusty ash formation.

3. *Coal Carbonization*

"Investigation of coal weathering and methods for determining it is again mentioned here, as was done under 'The Constitution of Coal,' since such information would have a direct application to deterioration in coking properties of coal.

4. *Water Gas Manufacture*

"The physical chemistry of blue water gas reactions has been rather thoroughly investigated, and it is doubtful whether there is much opportunity for thesis work along these lines. However, there appears to be some controversy regarding the source of methane present in blue water gas, and a physical chemical study of this would appear to be in order.

5. *Complete Gasification of Coal*

"This may be assumed to mean the use of oxygen and steam for gasification, thereby providing continuous gas production. A study of the literature will show several controversial points on which some light might be shed by thesis work.

6. *Gas Oils and Carburetion*

"The chemistry of the cracking of gas oils in the carburetor, the effect of the gaseous atmosphere, the temperature, effect of certain catalytic materials, etc., have all been studied to some extent, but it is believed a series of thesis subjects could be outlined that would fill in certain gaps in our information in this field.

7. *New Processes of Interest to the Gas Industry*

"R. T. Haslam in 1926 outlined several processes as being of especial interest to the gas industry:

"*a.* The manufacture of liquid fuels from gas or coal and its relation to catalytic enrichment of blue gas.

"*b.* The cracking of oil for the conjoint production of enriching gases and motor fuels.

"*c.* The development of small portable gas units for isolated homes.

"The above subjects have received much attention recently but still offer topics for academic research. At the present time this list could be enlarged and what was said earlier in this report regarding the following up of new developments applies here.

8. *Condensing and Scrubbing*

"Past committee work of the American Gas Association has been directed towards some of the practical and theoretical aspects of condensing and scrubbing. Several committees have functioned under the name of 'Committee on Condensing and Scrubbing,' and it is suggested that a study of these reports will bring to light certain unsolved problems admirably adapted to physical thesis work.

9. *Tar Refining and Tar Products*

"Water-gas tar has never been subjected to the same detailed study as has coal tar. An entire series of thesis investigations, including doctor's thesis, could be arranged on the chemical constitution of water-gas tar.

"In the analytical field there is need for an accurate, rapid method for determination of moisture in tar.

"Laboratory studies of tar emulsions, their nature and what causes them make some excellent thesis material.

10. *Light Oil Recovery and Refining*

"Despite the fact that light oil absorption and distillation depend on vapor pressure relationships, there are comparatively few data in the literature covering these relationships. An entire series of thesis investigations could profitably be arranged to obtain these data for various mixtures of absorbent oil, benzol, toluol, xylol, carbon disulphide, etc., at various temperatures.

11. *Ammonia Recovery*

"Although there are data on vapor pressures of ammonia from water solutions of different strengths and at different temperatures, some of the other systems have not been studied so thoroughly, for

example, the vapor pressures of systems containing water, ammonia and phenol, and possibly some of the minor constituents of ammonia liquor. The effect of temperature and concentration effects on the crystallization of ammonium sulphate would make an interesting study.

12. *The Recovery of By-Products Other than Tar, Ammonia, and Light Oil*

"Other by-products include phenol, pyridine, various cyanogen and thiosulphate compounds, sulphur from liquid purification processes, ethylene, and other products, some of which are recovered only in a limited number of plants. None of the possible research problems connected with recovery (or utilization) of these products are mentioned here, but a good many are known to exist and can be outlined by study of each individual recovery process.

13. *Gas Purification*

"Gas purification in its usual meaning includes only the removal of sulphur compounds, usually hydrogen sulphide, from gas. In its broader meaning it may include also the removal of hydrocyanic acid, water, oxygen, naphthalene, and indene and other resin-forming substances.

"The chemical reactions occurring in dry iron oxide purification have been determined rather conclusively. However, there appears to be some controversy concerning the effect of water of hydration on effectiveness of iron oxide. This point is worthy of further study and research.

"Spent iron oxide constitutes a serious disposal problem for the gas industry. Some study should be made of possible methods of utilization, keeping in mind the many failures of the past in trying to use it for certain purposes. Also some research should be conducted on a simple, convenient method for determining the cyanide content of spent oxide.

"The organic sulphur compounds in gas have never been investigated with sufficient thoroughness. It is understood that this problem is now being investigated at Johns Hopkins University.

"The determination of naphthalene in gas by methods other than those involving the use of picric acid should be investigated. Emphasis should be placed on the development of dew-point methods. A good naphthalene dew-point method, if accurate and rapid, would be of very considerable value to the gas industry.

"Analytical methods for the specific determination of indene and other resin- or gum-forming constituents in gas are needed.

14. *Corrosion*

"This is a broad subject and any research work that sheds light on the problem is of considerable interest and value.

"As applied to the gas industry, it is suggested that there is need of a thorough study of the corrosive effect of each constituent of gas. This should be attacked from several angles. Each constituent could be tested by itself, and then gas with each constituent removed successively could be tested. There is a good deal of confusion as to which constituents or combination of constituents is responsible for the worst corrosive effects, and a laboratory investigation under closely controlled conditions should throw some light on the subject.

15. *Materials of Construction*

"There are a great many research problems along this line, many of which are common to several industries. None of these will be listed here.

16. *Utilization of Manufactured Gas*

"This is a field of investigation of great interest to the gas industry. As has already been mentioned, there are many chemical and physical problems in gas utilization that could well be carried on as thesis work. None of these is given here, but it is suggested that those desiring to work in this field get in touch with the American Gas Association Testing Laboratory at Cleveland, Ohio.

17. *Analytical Methods and Tests*

"Several analytical methods have already been suggested as possible thesis subjects under the different phases of gas manufacture. A few more are suggested here.

"It is believed that the analysis of gas should be studied from more of a research viewpoint than in the past. This applies particularly to constituents which may be present in rather small amounts, such as oxygen, and to methane in blue water or producer gas. The illuminants should be given more study than in the past and especially is there need of good average figures to be used for heating value, specific heat, gravity, etc., of illuminants.

"There is need for a rapid, simple method for the determination of pyridine. Also, the determination of naphthalene content of oils is a rather difficult procedure at present, and might be improved.

"The need of a good dewpoint method for naphthalene in gas has already been cited, and is again mentioned because of its importance.

"A quick and accurate volumetric method for determining total sulphur in fuels would be most welcome. Past work on this subject has not resulted in any method that has been extensively accepted.

18. *Physical Methods of Control and Measurement*

"This includes all forms of metering, calorimetry and pyrometry, temperature and pressure measurements, etc. Some problems of this type have already been mentioned. This is an excellent field of research for physicists. Tests of accuracy of physical measuring equipment, the effect of the certain variables on accuracy, and other problems are too numerous to list in this report.

"Critical surveys of the published constants of materials used or produced by the gas industry, together with redetermination of confliction values, are always in order.

Conclusion

"The suggested fields and specific problems for thesis work which have been listed here are only some high spots that are typical of many more that can be found by study of past work and close observation of problems arising in connection with new developments in the industry. There are plenty of problems suitable in nature and scope for bachelor's, master's and doctor's theses. It is far from being, and is not intended to be, a complete list.

"It is important again to state that many of these subjects should be subdivided for thesis work, since it is a mistake to attempt to cover too much territory in the very limited time ordinarily available.

"The addenda given below were prepared by the writer at the suggestion of Mr. F. W. Sperr, Jr., in response to a letter received by him from Prof. H. H. Higbie of the University of Michigan, dated June 3, 1930, and earlier correspondence. Some of these research topics have already been mentioned by Dr. A. R. Powell in his report. These are repeated here for the purpose of emphasis. It will be understood, of course, that the following list is merely typical and is in no way intended to be exhaustive in scope. Also, it must be remembered that the topics given below do not represent virgin fields of scientific research, in many cases.

"1. The relation of X-ray studies of coal at various temperatures to its constitution and behavior during utilization, especially during carbonization.

"2. Investigation of forms of nitrogen in coal.

"3. In what form does nitrogen appear in coke?

"4. Develop a good quick volumetric method for determining sulfur in solid fuels.

"5. Develop an improved, quick and accurate method for the ultimate analysis of fuels.

"6. Why do some cokes show erratic results on ultimate analysis, the oxygen being less than zero?

"7. Is there any $(CN)_2$ in coal gas, or is it all there as HCN?

"8. What is the character and quantity of unusual sulfur compounds (that is, those other than H_2S and CS_2) in various commercial fuel gases?

"9. Study of the free energy of CS_2.

"10. Study of the reaction of H_2S with CO.

"11. Equilibria between light oil and its various constituents with water at different temperatures and pressures.

"12. Determination of vapor pressure of phenol and of tar acids in aqueous solutions of sodium phenolate.

"13. Determination of quantity and nature of organic sulfur compounds in typical American natural gases.

"14. Direct-reading dew-point apparatus for gases.

"15. Quick and easy method for field determination of hydrocarbon vapor dewpoints of gases."

United States Rubber Co.,
Market and South Streets,
Passaic, N. J.
Mr. W. A. Gibbons, Director, Development Department.

"Evaluation of effect of heat conductivity of air, steam and liquid films on heat conductivity of rubber.

"Absorption of vibration of rubber.

"Permanent set taken by rubber supports.

"More work on the physics and chemistry of the ultra pure rubber hydrocarbon.

"Study of the polymerization of di-olefines to give synthetic rubber.

"Nature of the behavior of inhibitors in rubber oils and gasolenes.

"Particle sizes of fillers, such as blacks, zinc oxide, etc.

"Nature and extent of wetting of fillers by rubber."